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THE ROENTGENOLOGIC DIAGNOSIS OF BONE TUMORS

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INTRODUCTION

SUCCESSFUL medical diagnosis is dependent upon a twofold knowledge—familiarity with disease and information concerning the patient. Knowledge of disease implies an acquaintance with the so-called clinical entities, and knowledge of the patient presupposes a form of analysis known as a case history and physical examination, the latter elaborated in recent years by a series of laboratory and instrumental methods, including the use of the roentgenogram. Since diagnosis is essentially a disclosure in the patient of changes identical in character with those predetermined for a given disease entity, it is obvious that no single method of examining the patient, however helpful, can dispense with an adequate knowledge of disease.

In diseases of the bone the advent of the roentgenogram has added so much to the clinician's ability to bring to light the form and locality of the lesion, that this instrumental method has come to be considered by many, not as an adjunct to the examination of the patient, but as a new short-cut to diagnosis. While typical cases of bone disease may be diagnosed with fair readiness by direct comparison with previous X-ray films properly labelled, the variability of the pathology in the bone from patient to patient, with the same form of tumor, is sufficiently great to render such a method inaccurate in cases of the borderline group. If those who employ the X-ray for diagnosis of diseases of bone wish to extend the reliability of this instrument to a larger percentage of bone lesions coming under observation, what is needed is not more and more reiteration concerning the typical X-ray picture of the various tumors of bone, but a more careful analysis on the one hand of the roentgen examination of bone, as a diagnostic instrument, and on the other, a more comprehensive knowledge of the separate neoplastic entities of bone.

As a diagnostic agent in tumors of the bone, the roentgenogram is of sufficient importance to justify the organization of present-day knowledge concerning tumors of bone, from the standpoint of the features disclosed by the X-ray film. Such an organization of the information derived from a study of over a thousand cases of the various forms of bone tumors has been made here and is based upon the capacity of the roentgenogram to depict changes in the seven groups of findings listed below.

(1) Whether the individual affected is young or old.

(2) Whether the lesion is single or multiple.

(3) Whether the lesion is medullary or periosteal in origin.

(4) Whether the effect of the lesion is bone-destructive or bone-formative.

(5) Whether the site is in the shaft, metaphysis, or epiphysis, and which bone is affected.

(6) Whether or not pathologic fracture has occurred.

(7) The configuration of the diseased area from which such data as the mode of origin and duration of the tumor may be deduced.

A summary of the results of the study is shown by chart (Fig. 1) and by tabulation (Table I). These diagrammatic representations are followed by a series of brief descriptions of the various neoplastic entities of bone, with representative illustrations. From the standpoint of differential diagnosis, bone diseases not of neoplastic nature have been included. As will be seen by the chart and from the sectional headings, the various tumors of bone have been grouped on the basis of whether or not they produce single or multiple involvement in the skeleton, whether they are more prevalent in patients under or over twenty, and whether the bone lesion is primarily osteolytic or osteoplastic in its effect. In the clinical descriptions which follow, something of the histogenesis of each tumor has been included, because a comprehension of the mode of origin of the neoplasm often permits an analysis of the X-ray film not otherwise possible. A list of the entities discussed is given below in the order of their frequency, with the number of cases analyzed in each group.

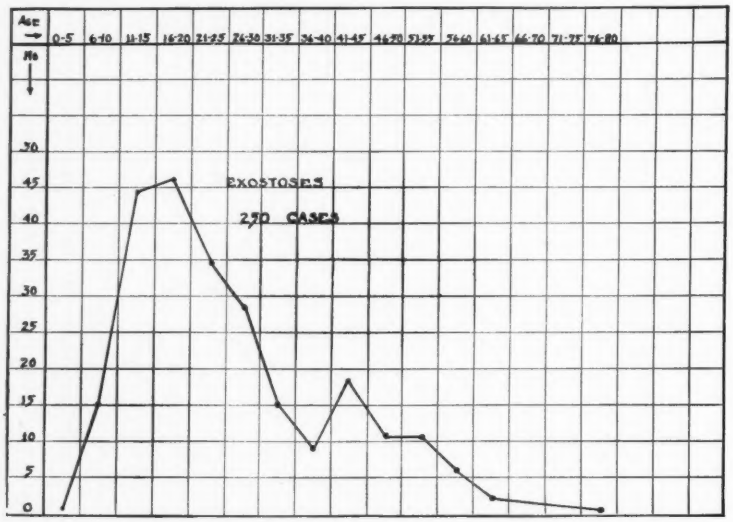


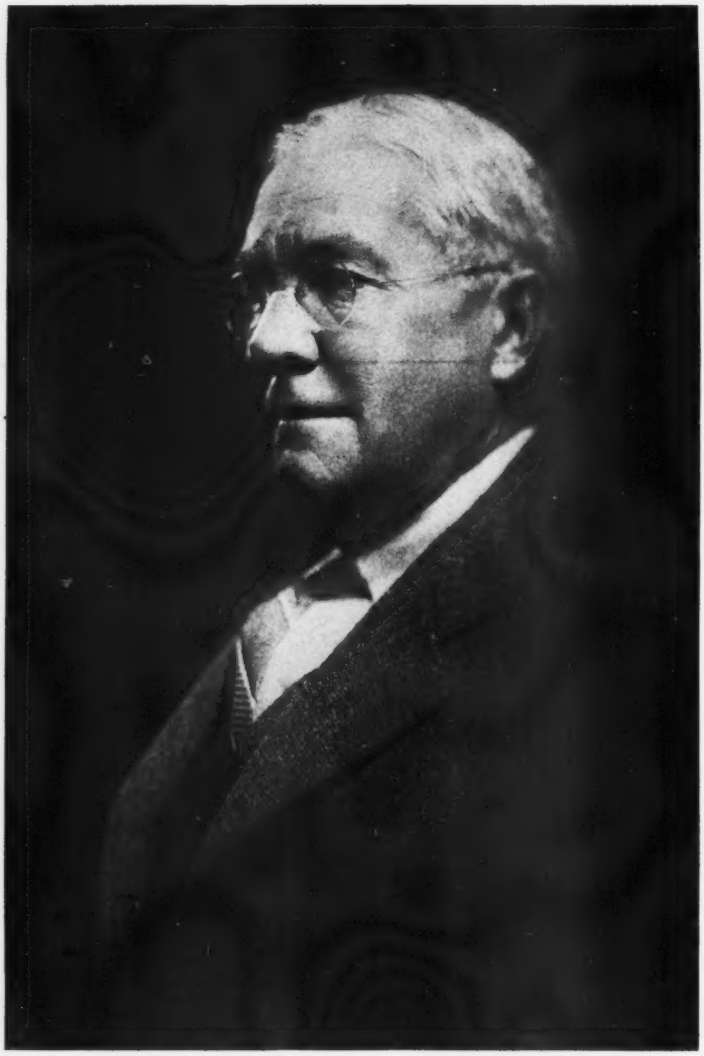
Fig. 2. Chart showing the age incidence of benign exostoses or osteochondromas.

ORDER OF DISCUSSION

Part A. Single Lesions

I. Osteoplastic lesions prevalent in patients under twenty
   1. Exostosis or osteochondroma
   2. Periosteal osteogenic sarcoma
   3. Ewing's sarcoma
   4. Garré's sclerosing osteitis

Summary



JOSEPH COLT BLOODGOOD, M.D., Johns Hopkins Hospital and University, Baltimore, to whom this issue is dedicated

UNDER 20 YRS

OSTEOPLASTIC

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LIVING

CONFIGU

EXOSTOSIS	OSTEOGENIC SARCOMA	EWING'S SARCOMA
BENIGN	MALIGNANT[H-F]	MALIGNANT[F]
10 - 20 YRS.	10 - 20 YRS	10 - 20 YR
LO. FEMUR UP. TIBIA UP. FEMUR UP. HUMERUS	UP. TIBIA LO. FEMUR	TIBIA FEMUR HUMERUS
5 YEARS 95%	6 MOS. 31% & 6 %	13 MOS. 12%
 PERIOSTEAL	 OSTEOPLASTIC CHONDRAL	DIFFUSE 

MULTIPLE EXOSTOSES	"MARBLE BONES"
BENIGN	BENIGN

ROENTGENOGRAPHIC DIAGNOSIS

FOR DISEASES AND TUMORS OF THE BONE

C. GESCHICKTER, M. D., JOHNS HOPKINS HOSPITAL, BALTIMORE,

SINGLE

OSTEOLYTIC

OST

	OSTEOLYTIC BONE CYST	OSTEOLYTIC SARCOMA	BRODIE'S ABSCESS	GIANT CELL TUMOR	CHONDROMA	LATEN BONE C
	BENIGN*	MALIGNANT	BENIGN	BENIGN*	BENIGN*	BENIG
DECADE	5 - 15 YRS.	10 - 20 YRS.	15 - 25 YRS.	20 - 30 YRS	20 - 30 YRS	35 - 45
BONES	UPPER HUMERUS UPPER TIBIA UPPER FEMUR	UPPER TIBIA LOWER FEMUR UPPER HUMERUS	TIBIA LOWER FEMUR LOWER HUMERUS	LO. RADIUS UP. TIBIA LO. FEMUR	PHALANGES HANDS & FEET STERNUM	FEMUR TIBIA
DURATION	30 MONTHS	10 MONTHS	1 - 3 YRS.	14 MOS.	5 YRS.	5 - 20
ING 5 YRS.	95%	11%	100%	85%	90%	100%
FIGURATION						
	MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY	MEDULL

	GARRE'S OSTEITIS	OSTEOMYELITIS	TUBERCULOSIS	SYPHILIS	MYXOSARCON
	BENIGN*	BENIGN	BENIGN	BENIGN	MALIGNANT**
	15 - 25 YRS.	3 - 12 YRS.	3 - 12 YRS.	20 - 30 YRS.	35 - 45 YRS.
	FEMUR TIBIA	UP. TIBIA LO. FEMUR LO. TIBIA	SPINE HIP KNEE	TIBIA SKULL STERNUM	LO. FEMUR UP. HUMERUS
	5 YEARS 85%	2 - 6 WEEKS 90%	18 MOS. 85%	2 - 5 YRS. 97%	6 YRS. 24%
	DIFFUSE				
		DIFFUSE	JOINT	DIFFUSE	DIFFUSE

	SCURVY
	BENIGN

TGENOGRAPHIC DIAGNOSI

FOR DISEASES AND TUMORS OF THE BONE

C. GESCHICKTER, M. D., JOHNS HOPKINS HOSPITAL, BALTIMORE

SINGLE

TIC

ST	OSTEOLYTIC SARCOMA	BRODIE'S ABSCESS	GIANT CELL TUMOR	CHONDROMA	LAT BONE
	MALIGNANT	BENIGN	BENIGN*	BENIGN*	BE
S.	10 - 20 YRS.	15 - 25 YRS.	20 - 30 YRS	20 - 30 YRS	35 -
US	UPPER TIBIA LOWER FEMUR UPPER HUMERUS	TIBIA LOWER FEMUR LOWER HUMERUS	LO. RADIUS UP. TIBIA LO. FEMUR	PHALANGES HANDS & FEET STERNUM	FEMU TIBI
	10 MONTHS 11%	1 - 3 YRS. 100%	14 MOS. 85%	5 YRS. 90%	5 - 10
					
	MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY	MED

OSTEOMYELITIS	TUBERCULOSIS	SYPHILIS	MYXOSAR
BENIGN	BENIGN	BENIGN	MALIGNAN
3 - 12 YRS.	3 - 12 YRS.	20 - 30 YRS.	35 - 45 Y
UP. TIBIA LO. FEMUR LO. TIBIA	SPINE HIP KNEE	TIBIA SKULL STERNUM	LO. FEMUR UP. HUMER
2 - 6 WEEKS 90%	18 MOS. 85%	2 - 5 YRS. 97%	6 YRS. 24%
			
DIFFUSE	JOINT	DIFFUSE	DIFFUS

SIS CHART

ONE

ORE, MD.

OSTEOLYTIS

OVER 20 YRS.

OSTEOPLASTIC

LATENT BONE CYST	SINGLE METASTATIC
BENIGN	MALIGNANT*
35 - 45 YRS	55 - 65 YRS
FEMUR	FEMUR
TIBIA	HUMERUS
5 - 20 YRS.	18 MOS.
100%	1%
	
MEDULLARY	MEDULLARY

SARCOMA
GNANT**
45 YRS.
EMUR
UMERUS
3.

FFUSE

FIBRO-SARCOMA	MYOSITIS OSSIFICANS	OSSIFYING PERIOSTITIS
MALIGNANT*	BENIGN	BENIGN*
30 - 40 YRS.	20 - 30 YRS.	20 - 30 YRS.
LO. FEMUR	THIGH	FEMUR
UP. TIBIA	ELBOW	TIBIA
		SKULL
		HUMERUS
30 MOS.	6 WEEKS	2 - 5 YRS.
41%	92%	97%
		
PERIOSTEAL	PERIOSTEAL	PERIOSTEAL

OSTEITIS DEFORMANS	OSTEO-ARTHRITIS
BENIGN	BENIGN

OSTEOPLASTIC

EXOSTOSIS	OSTEOGENIC SARCOMA	EWING'S SARCOMA
BENIGN	MALIGNANT**	MALIGNANT*
10 - 20 YRS.	10 - 20 YRS.	10 - 20 YRS.
LO. FEMUR UP. TIBIA UP. FEMUR UP. HUMERUS	UP. TIBIA LO. FEMUR	TIBIA FEMUR HUMERUS
5 YEARS	6 MOS.	13 MOS.
95%	31% & 6 %	12%
 PERIOSTEAL	 OSTEOPLASTIC CHONDRAL	 DIFFUSE

MULTIPLE EXOSTOSES	"MARBLE BONES"	S
BENIGN	BENIGN	
10 - 20 YRS.	10 - 20 YRS.	6
FORELEG FOREARM	SKULL LONG BONES	
5 YRS. PLUS	5 YRS. PLUS	6
98%	20%	
 PERIOSTEAL	 MEDULLARY	PE

OSTEOPLASTIC

UNDER 20YRS.

MEDULLARY | MEDULLARY | MEDULLARY | MEDULLARY | MEDULLARY | MEDULL

GARRE'S OSTEITIS	OSTEOMYELITIS	TUBERCULOSIS	SYPHILIS	MYXOSARCOM
BENIGN*	BENIGN	BENIGN	BENIGN	MALIGNANT**
15 - 25 YRS.	3 - 12 YRS.	3 - 12 YRS.	20 - 30 YRS.	35 - 45 YRS.
FEMUR TIBIA	UP. TIBIA LO. FEMUR LO. TIBIA	SPINE HIP KNEE	TIBIA SKULL STERNUM	LO. FEMUR UP. HUMERUS
5 YEARS 85%	2 - 6 WEEKS 90%	18 MOS. 85%	2 - 5 YRS. 97%	6 YRS. 24%
DIFFUSE	DIFFUSE	JOINT	DIFFUSE	DIFFUSE

SCURVY
BENIGN
6 - 10 MOS.
JAWS LONG BONES
6 WEEKS
95%
PERIOSTEAL

GIVEN THE AGE OF THE PATIENT, WHETHER TH
SINGLE OR MULTIPLE, OSTEOPLASTIC OR OST
IN THE SECTOR THUS DETERMINED WIL
THE DIAGNOSTIC POSSIBILITIES

*Deep X-Ray Therapy helpful

**Radium Therapy helpful in Chon
and Myxosarcoma

RICKETS	OSTEOGENESIS IMPERFECTA	FRAGILITAS OSSIUM	METASTATIC CARCINOMA	MULTIPLE MYELOMA
BENIGN	BENIGN	BENIGN	MALIGNANT*	MALIGNANT
1 - 3 YRS.	0 - 10 YRS.	5 - 15 YRS.	55 - 65 YRS.	50 - 60 YRS.
RIBS SKULL LONG BONES	ENTIRE SKELETON	LONG BONES SKULL TRUNK	SPINE PELVIS FEMUR	SPINE RIBS STERNUM
2 - 5 MOS. 95%	AT BIRTH 5%	5 YRS. PLUS 85%	18 MOS. 0%	15 - 24 MOS. 0.3%
EPIPHY SEAL				

MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY	MEDU

OSTEOMYELITIS	TUBERCULOSIS	SYPHILIS	MYXOSARC
BENIGN 3 - 12 YRS. UP. TIBIA LO. FEMUR LO. TIBIA 2 - 6 WEEKS 90%	BENIGN 3 - 12 YRS. SPINE HIP KNEE 18 MOS. 85%	BENIGN 20 - 30 YRS. TIBIA SKULL STERNUM 2 - 5 YRS. 97%	MALIGNANT 35 - 45 YRS LO. FEMUR UP. HUMERUS 6 YRS. 24%
			
DIFFUSE	JOINT	DIFFUSE	DIFFUSE

VEN THE AGE OF THE PATIENT, WHETHER T
SINGLE OR MULTIPLE, OSTEOPLASTIC OR OS
IN THE SECTOR THUS DETERMINED WI
THE DIAGNOSTIC POSSIBILITIES

*Deep X-Ray Therapy helpful

**Radium Therapy helpful in Ch
and Myxosarcoma

	OSTEOGENESIS IMPERFECTA	FRAGILITAS OSSIUM	METASTATIC CARCINOMA	MULTIPLE MYELOMA
	BENIGN 0 - 10 YRS. ENTIRE SKELETON AT BIRTH 5%	BENIGN 5 - 15 YRS. LONG BONES SKULL TRUNK 5 YRS. PLUS 85%	MALIGNANT* 55 - 65 YRS. SPINE PELVIS FEMUR 18 MOS. 0%	MALIGNANT 50 - 60 YRS. SPINE RIBS STERNUM 15 - 24 MOS. 0.3%
				

EDULLARY | MEDULLARY

ARCOMA
ANT**
YRS.
UR
ERUS
USE

FIBRO-SARCOMA	MYOSITIS OSSIFICANS	OSSIFYING PERIOSTITIS
MALIGNANT*	BENIGN	BENIGN*
30 - 40 YRS.	20 - 30 YRS.	20 - 30 YRS.
LO. FEMUR UP. TIBIA	THIGH ELBOW	FEMUR TIBIA SKULL HUMERUS
30 MOS. 41%	6 WEEKS 92%	2 - 5 YRS. 97%
		
PERIOSTEAL	PERIOSTEAL	PERIOSTEAL

OSTEITIS DEFORMANS	OSTEO-ARTHRITIS
BENIGN	BENIGN
45 - 55 YRS.	45 - 55 YRS.
TIBIA SKULL PELVIS	HIP KNEES FINGERS
2 - 5 YRS. 95%	5 - 10 YRS. 100%
	
PERIOSTEAL	JOINTS

THE LESION IS
OSTEOLYTIC,
WILL BE
S

n Chondral

A	OSTEOMALACIA
S.	BENIGN 30 - 50 YRS.
	PELVIS SPINE FEMURS
S.	2 - 5 YRS. 65%
	

OSTEOPLASTIC

OSTEOPLASTIC

OVER 20 YRS

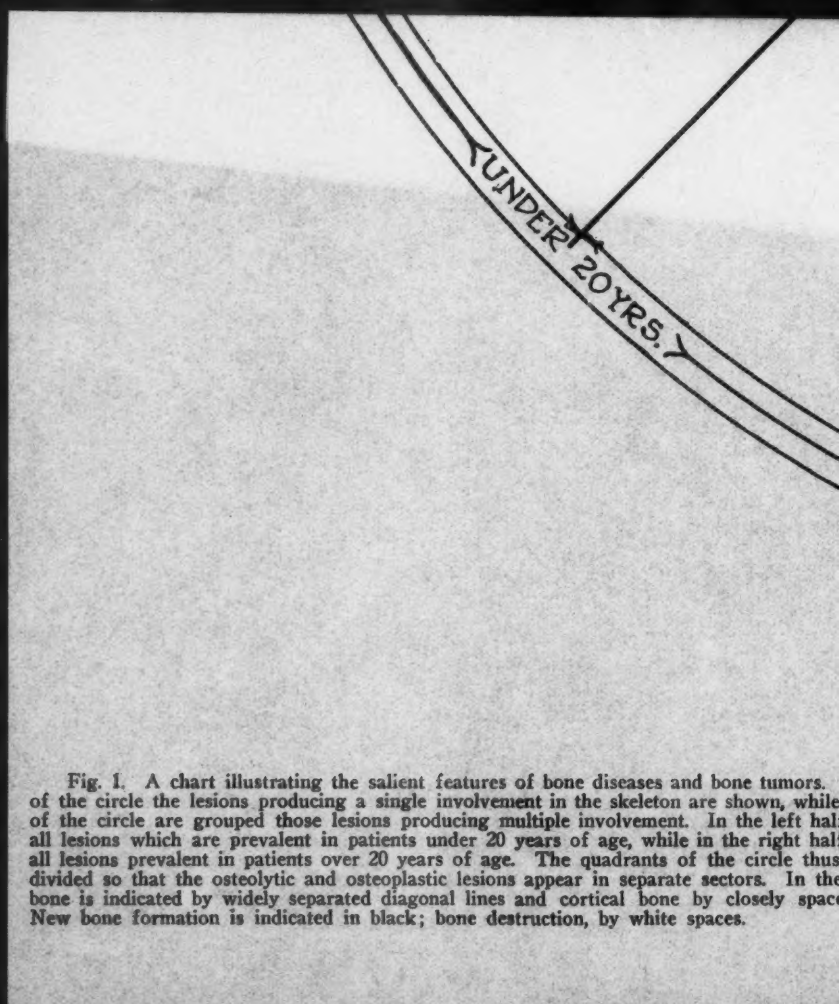
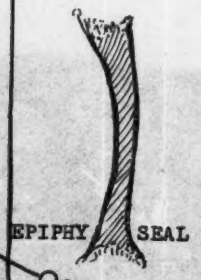


Fig. 1. A chart illustrating the salient features of bone diseases and bone tumors. of the circle the lesions producing a single involvement in the skeleton are shown, while of the circle are grouped those lesions producing multiple involvement. In the left hal all lesions which are prevalent in patients under 20 years of age, while in the right hal all lesions prevalent in patients over 20 years of age. The quadrants of the circle thus divided so that the osteolytic and osteoplastic lesions appear in separate sectors. In the bone is indicated by widely separated diagonal lines and cortical bone by closely spac New bone formation is indicated in black; bone destruction, by white spaces.

RIBS SKULL LONG BONES 2 - 5 MOS. 95%	ENTIRE SKELETON AT BIRTH 5%	LONG BONES SKULL TRUNK 5 YRS. PLUS 85%	SPINE PELVIS FEMUR 18 MOS. 0%	SPINE RIBS STERNUM 15 - 24 MOS. 0.3%
				
MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY	MEDULLARY

OSTEOLYTIC

OST

MULTIPLE

nors. In the upper half while in the lower half ft half of the circle are nt half of the circle are e thus formed are sub- In the chart, cancellous spaced diagonal lines.

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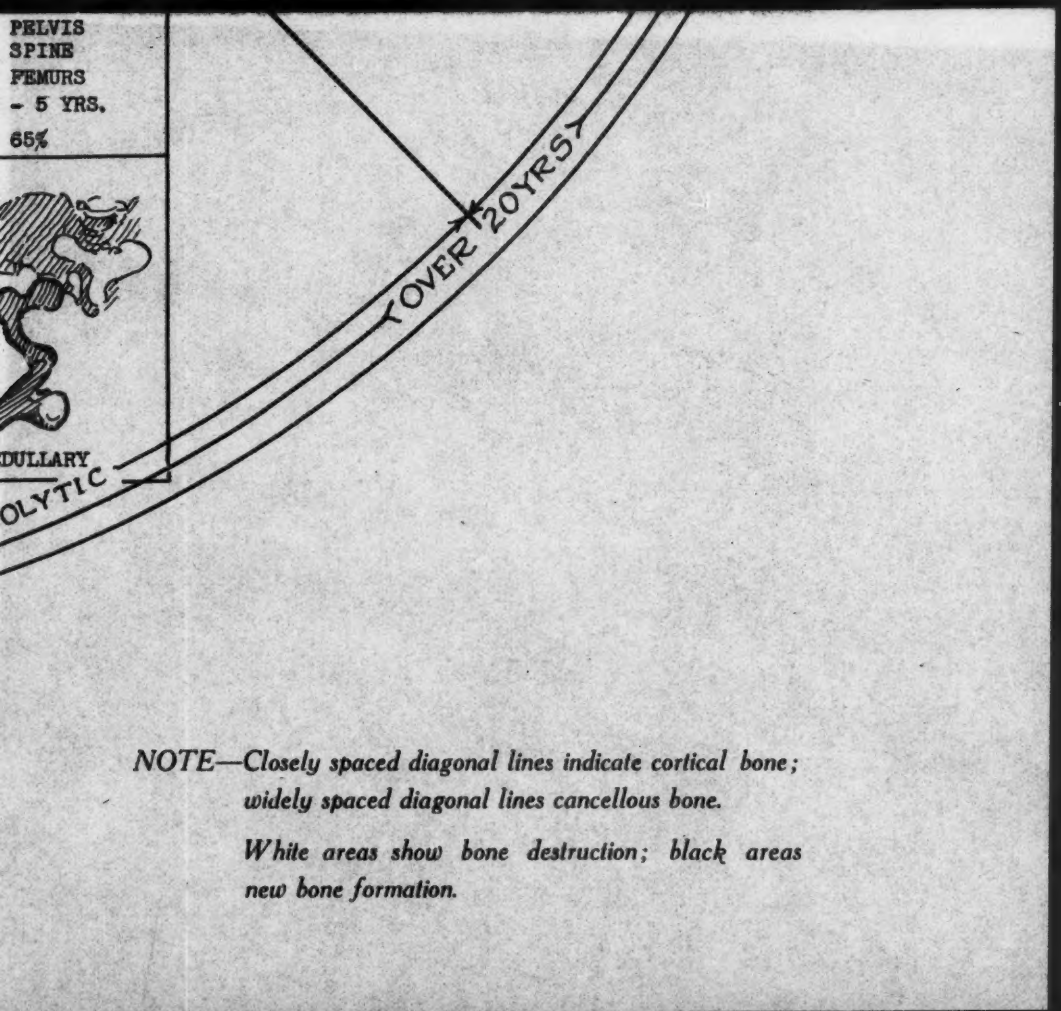


NOTE—Closely spaced diagonal lines indicate cortical bone; widely spaced diagonal lines cancellous bone.

White areas show bone destruction; black areas new bone formation.

II. Osteolytic lesions prevalent in patients under twenty
   1. Benign bone cyst
   2. Osteogenic sarcoma of the osteolytic type
   3. Brodie's abscess
      Summary

III. Tuberculosis, syphilis, osteomyelitis, and myxosarcoma
   1. Myxosarcoma
   2. Osteomyelitis
      Tuberculosis of bone
      Syphilis of bone

IV. Ossifying periosteal lesions prevalent in adults
   1. Periosteal fibrosarcoma
   2. Myositis ossificans
   3. Ossifying periostitis.
      Summary

V. Osteolytic lesions prevalent in adults
   1. Benign giant-cell tumor
   2. Chondroma
   3. Metastatic carcinoma (single focus)
   4. Latent bone cyst
   5. Multiple myeloma (single focus)
      Summary

Part B. Multiple Lesions

I. Multiple osteoplastic lesions prevalent in patients under twenty
   1. Multiple exostoses
   2. Marble bones
   3. Infantile scurvy
      Summary

II. Multiple osteolytic lesions prevalent in patients under twenty
   1. Metastatic osteomyelitis
   2. Bone fragility
   3. Rickets
      Summary

III. Multiple osteoplastic lesions prevalent in adults
   1. Osteitis deformans

IV. Multiple osteolytic lesions prevalent in adults
   1. Metastatic carcinoma
   2. Multiple myeloma
   3. Osteomalacia
      Summary

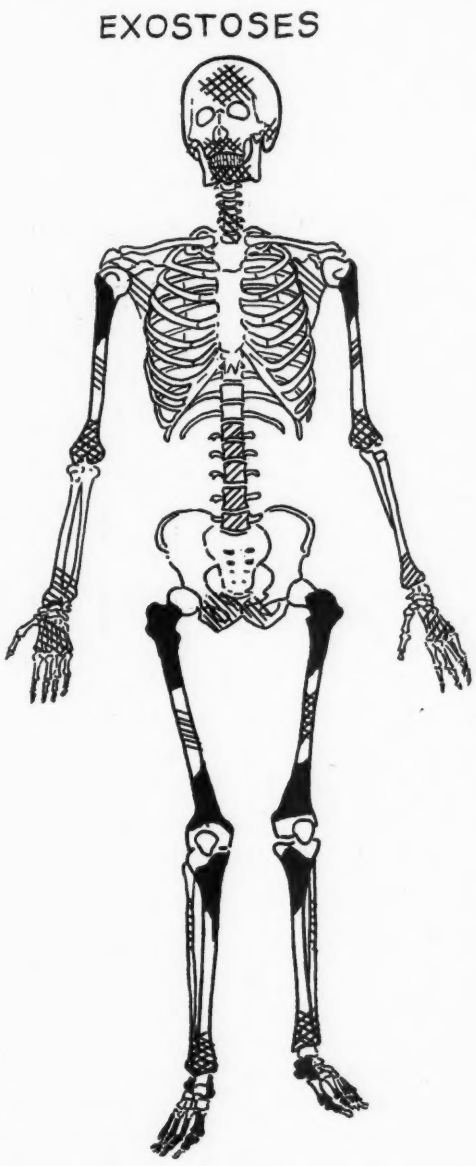


Fig. 3. Chart showing the incidence of benign exostoses according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

TABLE 1

CLASSIFICATION OF BONE DISEASES AND BONE TUMORS ACCORDING TO ROENTGENOLOGIC FEATURES

Age		Foci		Distribution				Locus		Effect	
0-20	21-70	Single	Multiple	Bone	Shaft	Metaphysis	Epiphysis	Medullary	Periosteal	Osteolytic	Osteoplastic
Exostoses	....	Exostoses	....	Lo. femur, up. tibia	Exostoses	Exostoses	....	....	Exostoses	....	Exostoses
Periosteal sarcoma	....	Periosteal sarcoma	....	Lo. femur, up. tibia	....	Periosteal sarcoma	....	....	Periosteal sarcoma	....	Periosteal sarcoma
Ewing's sarcoma	....	Ewing's sarcoma	....	Tibia, femur	Ewing's sarcoma	....	....	Ewing's sarcoma (late)	Ewing's sarcoma (early)	Ewing's sarcoma (late)	Ewing's sarcoma (early)
Garré's osteitis	....	Garré's osteitis	....	Tibia, femur	Garré's osteitis	....	....	Garré's osteitis (late)	Garré's osteitis (early)	Garré's osteitis (late)	Garré's osteitis (early)
Bone cyst	....	Bone cyst	....	Up. humerus, up. tibia	Bone cyst	Bone cyst	....	Bone cyst	....	Bone cyst	....
Osteolytic sarcoma	....	Osteolytic sarcoma	....	Femur, tibia	Osteolytic sarcoma	Osteolytic sarcoma	Osteolytic sarcoma	Osteolytic sarcoma	....	Osteolytic sarcoma	....
Brodie's abscess	....	Brodie's abscess	....	Tibia, femur	....	Brodie's abscess	....	Brodie's abscess	....	Brodie's abscess	....
....	Myxosarcoma	Myxosarcoma	....	Femur, tibia	....	Myxosarcoma	Myxosarcoma	Myxosarcoma	Myxosarcoma	Myxosarcoma	Myxosarcoma
Osteomyelitis	....	Osteomyelitis	....	Up. tibia, lo. femur	....	Osteomyelitis	Osteomyelitis	Osteomyelitis	Osteomyelitis	Osteomyelitis	Osteomyelitis
Tuberculosis	....	Tuberculosis	....	Spine, knee, hip, ankle	....	Tuberculosis	Tuberculosis	Tuberculosis	....	Tuberculosis	....
....	Syphilis	Syphilis	....	Tibia, skull	Syphilis	....	....	Syphilis (late)	Syphilis (early)	Syphilis (late)	Syphilis (early)
....	Fibrosarcoma	Fibrosarcoma	....	Lo. femur, up. tibia	Fibrosarcoma	....	....	....	Fibrosarcoma	Fibrosarcoma	....
....	Myositis ossificans	Myositis ossificans	....	Thigh, elbow	Myositis ossificans	Myositis ossificans	....	....	Myositis ossificans	....	Myositis ossificans
....	Giant-cell tumor	Giant-cell tumor	....	Lo. femur, lo. radius	....	....	Giant-cell tumor	Giant-cell tumor	....	Giant-cell tumor	....
....	Chondroma	Chondroma	....	Hands, feet	Chondroma	....	....	Chondroma	....	Chondroma	....
....	Bone cyst, latent	Bone cyst, latent	....	Femur, tibia	Bone cyst, latent	....	....	Bone cyst, latent	....	Bone cyst, latent	....

....	Metastatic carcinoma	Metastatic carcinoma	Spine, pelvis	Metastatic carcinoma	Metastatic carcinoma	....	Metastatic carcinoma	....	Metastatic carcinoma	....	Metastatic carcinoma	....	Metastatic carcinoma
....	Multiple myeloma	....	Spine, ribs	Multiple myeloma	Multiple myeloma	....	Multiple myeloma	....	Multiple myeloma	....	Multiple myeloma	....	....
....	Osteo-malacia	....	Spine, pelvis	Osteo-malacia	....	....	Osteo-malacia	....	Osteo-malacia	....	Osteo-malacia	....	....
....	Osteitis deformans	....	Skull, tibia	Osteitis deformans	....	....	....	Osteitis deformans	....	Osteitis deformans	Osteitis deformans	Osteitis deformans	Osteitis deformans
Multiple exostoses	....	....	Forearm, leg	....	Multiple exostoses	....	....	Multiple exostoses	....	Multiple exostoses	....	....	Multiple exostoses
Marble bones	....	....	Legs, arms	....	Marble bones	Marble bones	Marble bones	....	Marble bones	....	Marble bones	....	Marble bones
Fragile bones	....	....	Long bones	Fragile bones	Fragile bones	Fragile bones	Fragile bones	....	Fragile bones	....	Fragile bones	....	....
Rickets	....	....	Ribs, skull, long bones	....	....	Rickets	Rickets	....	Rickets	....	Rickets	....	....
Scurvy	....	....	Long bones, jaw	Scurvy	....	....	....	Scurvy	....	Scurvy	....	....	Scurvy

TABLE II

TABLE OF BONE LESIONS IN ORDER OF FREQUENCY

Metastatic carcinoma	300 cases
Periosteal osteogenic sarcoma	260 cases
Osteochondroma (exostosis)	260 cases
Giant-cell tumor	230 cases
Bone cysts	170 cases
Osteolytic osteogenic sarcoma	100 cases
Garré's sclerosing osteomyelitis[1]	100 cases
Myxosarcoma	80 cases
Chondromyxoma	70 cases
Ewing's sarcoma	65 cases
Periosteal fibrosarcoma	40 cases
Latent bone cysts	30 cases
Myositis ossificans	30 cases
Multiple bone cysts and osteomalacia	25 cases
Paget's osteitis deformans	20 cases
Multiple myeloma	20 cases
Brodie's abscess	20 cases
Fragile bones	5 cases
Total	1825 cases
Osteomyelitis	1312 cases
Tuberculosis	101 cases
Syphilis	30 cases

[1]Including ossifying periostitis.

PART A

NEOPLASTIC ENTITIES OF BONE OCCURRING AS SOLITARY LESIONS

Most of the lesions which the diagnostician is called upon to differentiate in the roentgenogram occur as a single area of involvement in one of the long pipe bones. If multiple involvement of the skeleton occurs, with changes in the pelvis, spine, and skull, the possibilities are at once limited to a more restricted group, and the problem of differential diagnosis greatly simplified. Because of this direct bearing upon the diagnosis, the solitary or multiple nature of the bone involvement has been used as the primary basis of classification in grouping the tumors studied from the standpoint of X-ray diagnosis. The various types of single lesions of bone are discussed first under the following sectional headings: I. Osteoplastic Lesions Prevalent in Patients under Twenty; II. Osteolytic Lesions Prevalent in Patients under Twenty; III. Tuberculosis, Syphilis, Osteomyelitis, and Myxosarcoma; IV. Ossifying Periosteal Lesions Prevalent

in Adults; V. Osteolytic Lesions Prevalent in Adults.

I. Osteoplastic Lesions Prevalent in Patients under Twenty

This group of lesions which comprises the benign exostoses, periosteal osteogenic sarcomas, Ewing's sarcoma, and Garré's sclerosing osteomyelitis, includes the most frequent forms of bone tumor—the exostoses and osteogenic sarcomas together forming by far the largest group. Although all four of these clinical entities may be designated as periosteal bone-forming lesions in accordance with conventional terminology, yet the exact mode and site of ossification varies widely within this group. In the exostoses or osteochondromas, the bone formation in the tumor is in reality an outgrowth of normal cortical and cancellous bone through a congenital periosteal defect. In the periosteal osteogenic sarcomas, two separate kinds of ossification occur, dependent upon the histologic variety of the tumor. In the osteoblastic osteogenic sarcoma, tumor bone originates in the subperiosteal zone and rapidly permeates the haversian system of the cortex, gaining entrance to the medullary cavity. In the chondral form of osteogenic sarcoma, the tumor gives rise to calcification and not primary bone, the small spicules of bone which may be present usually occurring as a reaction in the raised periosteum. In Ewing's sarcoma and in Garré's sclerosing osteomyelitis, bone formation is entirely secondary in its occurrence, and is stimulated

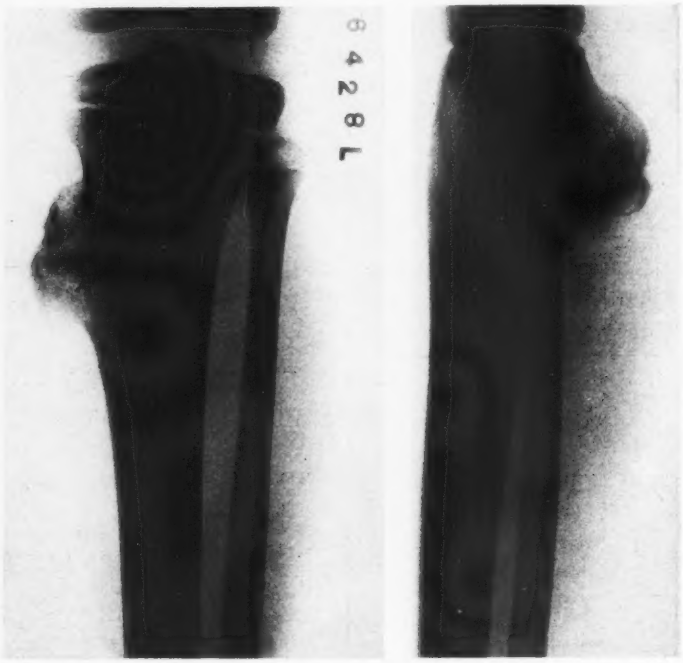


Fig. 4. Roentgenogram of a typical benign exostosis of the upper tibia. The normal bone bulges out to meet the neoplastic cartilaginous cap and forms a base or pedicle for the growth. Lines of calcification are present in the cartilaginous portion.*

*Photography by Mr. Herman Schapiro.

in the endosteum, cortex, and periosteum by invasion of the lymphatics—by tumor cells in the former instance, and by a low grade infection in the latter.

1. Exostoses or osteochondromas.—The osteochondromas or exostoses are benign tumors, usually occurring between the ages of ten and twenty-five years (Fig. 2) near the metaphyseal ends of the long bones and forming bony skeletal outgrowths with a thin cartilaginous cap. The symptoms in persons thus affected are generally mild and of long duration, averaging over five years in the cases of the present series. Males are affected approximately one and one-half times as often as females, and in 90 per cent of the patients there is but a single area of bone involvement. The distribution in the skeleton of these periosteal bone formative tumors is, in the order of frequency of the region affected, the lower femur and upper tibia about the knee, the lower tibia and os calcis about the ankle, the upper humerus at the shoulder, and the greater trochanter of the femur at the hip (Fig. 3). While a definite number of the osteochondromas escape clinical observation because of the absence of symptoms, the majority give evidence of their presence by painless swelling of the bone or by stiffness, with rheumatic aches in the neighboring joint.

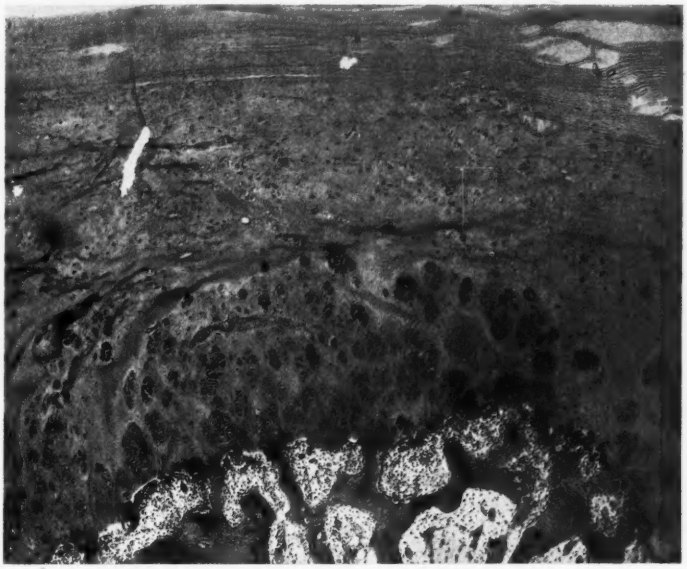


Fig. 5. Photomicrograph showing the three zones of tissue characteristic of a benign exostosis or osteochondroma. In the upper part of the section there is connective tissue continuous with the tendon. Beneath this there is cartilage, showing fetal cartilage, adult cartilage, and calcifying chondral tissue. Beneath the cartilage is cancellous bone enclosing marrow tissue.

In the roentgenogram the configuration of the tumor is readily analyzed into two separate portions, a base or pedicle of normal bone and a cartilaginous cap of neoplastic tissue (Fig. 4). The slow growth of the tumor is portrayed in the roentgenogram by the differentiation of the base or pedicle into zones of normal cancellous and compact bone and by calcification in the overlying cartilaginous cap. The morphology of the osseous portion of the tumor varies

from a narrow elongated pedicle to that of a broad flattened base or platform. The cartilaginous cap may be insignificant and nearly invisible or may overgrow the rest of the tumor with a large cauliflower mass.

formation of the attachment by cartilaginous ossification within the substance of the tendon. The exostosis or osteochondroma represents a failure accurately to approximate the juncture of these different tissues. As

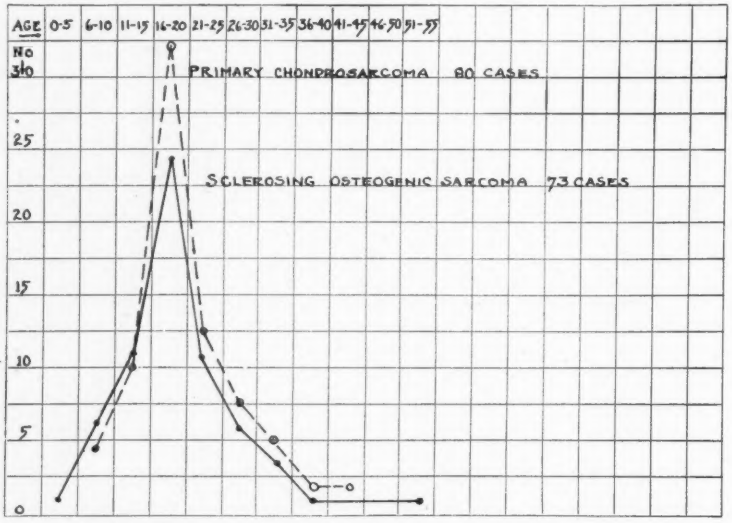
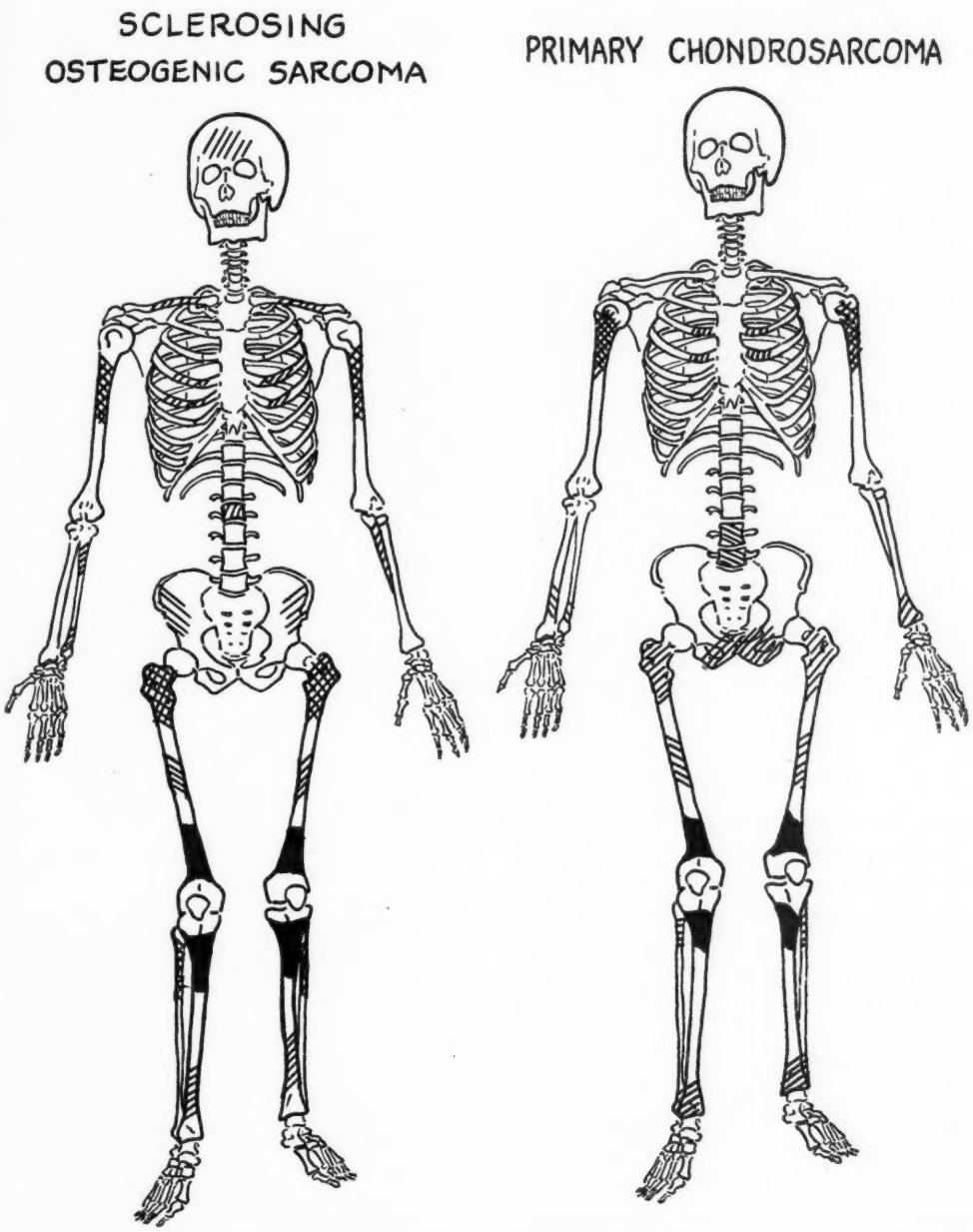


Fig. 6. Chart showing the age incidence of periosteal osteogenic sarcoma. The solid line indicates sclerosing osteogenic sarcoma derived from osteoblasts and the broken line indicates the cases of primary chondrosarcoma.

An overlying bursa containing fluid or calcified material may be definitely visible in the X-ray film. Pathologic fracture is extremely rare, occurring in approximately 1 per cent of the cases, and always takes place through the pedicle of the lesion rather than through the shaft of the underlying bone.

The histogenesis of these lesions is valuable in interpreting the X-ray findings. These neoplasms occur at the site of a congenital defect in the periosteum, the defect arising at a point in the bone predestined for some important tendinous insertion, such as the quadriceps femoris, the adductor magnus, or the Achilles tendon. At this junction Nature provides for a normal protuberance of bone, which bulges through a normal gap in the periosteum to meet an adjoining tendon, which co-operates in the

a result the normal bone protrudes excessively through the widened periosteal gap, forming the base or pedicle of the exostosis, and the cartilaginous center of ossification in the tendon reduplicates in excess, forming the large cauliflower cap typical of the osteochondromas or exostoses. This mode of origin is not only traceable in the roentgenograms, but is also borne out microscopically (Fig. 5). The significance of this histogenic analysis for roentgen-ray diagnosis lies in the fact that the bulging of the normal underlying bone through a periosteal gap to form a base or pedicle always points to the existence of an exostosis or osteochondroma, regardless of the size or form of the cartilaginous cap and whether or not secondary changes therein have occurred (1, 2).



Figs. 7-*A* and 7-*B*. Figure 7-A shows the incidence of sclerosing osteogenic sarcoma according to skeletal location, and Figure 7-*B*, the incidence of primary chondrosarcoma. The solid black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

While a favorable prognosis may be given all cases with typical exostoses and surgical intervention is not warranted in patients with mild or no symptoms, yet recurrences may follow incomplete excision or failure to approximate the soft parts over the peri-

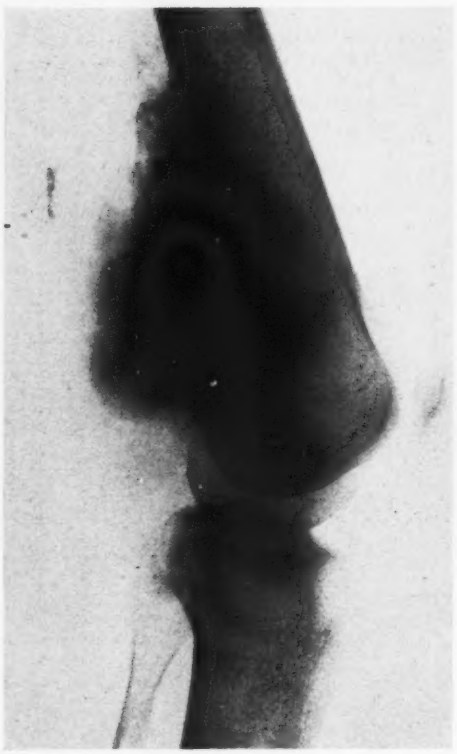


Fig. 8 *(left)*. Roentgenogram showing a typical sclerosing osteogenic sarcoma, with dense shaggy new bone formation beneath the periosteum in the metaphyseal region, and sclerosis of the marrow cavity.

Fig. 9 *(right)*. Typical roentgenogram of a primary chondrosarcoma, showing the translucent periosteal shadow and the delicate lines of calcification next to the bone. The cortex and medulla of the bone are not involved.

osteal gap. Secondary malignant change occurs in a definite percentage of these tumors, resulting in a slow growing chondromyxosarcoma. This malignant change, however, always gives warning of its occurrence by rapid increase in the size of the tumor, increased severity of the symptoms, and lytic changes in both the chondral and osseous portions of the neoplasm. These secondary malignant growths are discussed subsequently under Myxosarcoma *(which see)*.

2. Periosteal osteogenic sarcoma.—Periosteal osteogenic sarcoma, which results fatally in between 70 and 90 per cent of all cases, is the most frequent form of primary bone tumor. Among patients with this disease, males outnumber females in proportion of nearly two to one, and patients in the decade between ten and twenty years are affected approximately four times as often as in any other decade (Fig. 6).

Osteogenic sarcoma is practically never a multiple lesion in bone and in only the rarest instances does it metastasize to other bones. The usual form shows a periosteal zone of new bone formation classically at right-angles to the cortex. This new bone formation may be very delicate or very shaggy. It may produce sclerosis in the underlying cortex and marrow cavity, with some bone destruction, or it may not in-

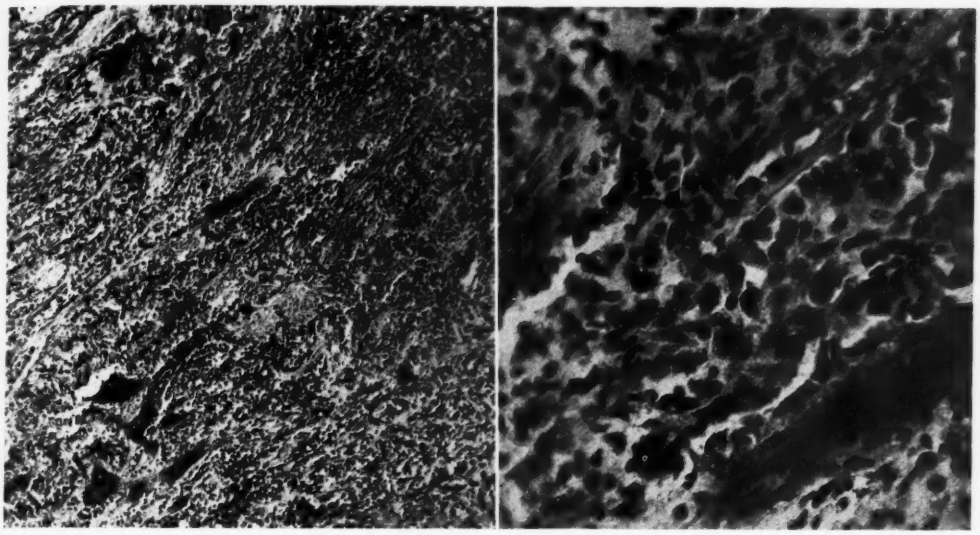


Fig. 10. Low and high power photomicrographs of sclerosing osteogenic sarcoma. The tumor is composed of malignant osteoblasts derived from fibroblasts. There is an irregular formation of osteoid spicules.

volve these cortical and medullary regions. Such variation is not due to an inconsistency in the nature of the tumor, but, rather, to an error in histogenic analysis, because the usual tumor referred to as a periosteal osteogenic sarcoma is not a single entity but in reality comprises two types of sarcoma, a true periosteal chondrosarcoma and a more diffuse subperiosteal osteoblastic sarcoma. These two types are approximately equal in frequency of occurrence. They both involve most frequently the metaphyseal regions of the lower femur and the upper tibia about the knee, but nevertheless they can be definitely distinguished both in the X-ray film and under the microscope. The importance of differentiating between these two forms of periosteal osteogenic sarcoma lies in the difference in prognosis; the osteoblastic form is curable by amputation in about 30 per cent of the cases, whereas the chondrosarcoma offers less than 10 per cent of chances of eradication, by even the most radical form of therapy.

Both the osteoblastic and chondral forms of osteogenic sarcoma give similar symptoms of rapidly increasing pain and swelling followed by a dysfunction of the affected limb. The chondrosarcoma shows its more malignant nature by the briefer duration of symptoms, the average being under six months in this group, while that of the osteoblastic form averages ten months. Pathologic fracture practically never occurs in either form of growth.

On the X-ray film the osteoblastic form of osteogenic sarcoma shows very shaggy and heavy lines of radiating new bone formation projecting in the periosteal region. This dense newgrowth is not confined, however, to the periosteal zone, but invades the marrow cavity, producing mottling and sclerosis (Figs. 7-*A* and 7-*B*). In a series of nearly a hundred cases the region of involvement is practically without exception metaphyseal, the epiphysis being occasionally involved secondarily by extension in its medullary portion. The borders of the in-

volved area are exceedingly irregular. In most cases the earliest signs of the new-growth are spicules of new bone emanating at right-angles from the cortex in the periosteal zone. In some cases, however, the pattern of bone formation is less distinct, while in others the only evidence of the tumor is the dense sclerosed area visible in the medullary region, with very little hazing in the periosteal zone. So-called lipping of the periosteum, characterized by the triangular area of elevation with a thin marking of new bone at the outer margin, is frequently seen on the side of the tumor area toward the mid-shaft.

Roentgenologic evidence of the presence of the chondral form of osteogenic sarcoma is never as pronounced in the X-ray film as the osteoblastic form, because most of the cartilaginous substance of the tumor is highly translucent or invisible in the film. Three important features combine to give the typical X-ray picture of ossifying chondrosarcoma a characteristic appearance: the faintly visible, semi-translucent soft-part shadow next the bone, the raising of the neighboring periosteum in more or less parallel layers, and the frequent absence of cortical or medullary bone involvement. The bulk of the tumor is extra-cortical, and

Fig. 11. Photomicrograph of a primary chondrosarcoma. There is a proliferation of small embryonic connective tissue cells in the lower portion of the picture, from which fetal and adult cartilage are developing. In the upper portion of the picture, there is calcification of cartilage and new bone formation. This tumor, therefore, is repeating the entire histogenesis of bone, showing the transition from connective tissue to cartilage and calcified cartilage to bone. The section is taken from a metastatic lung nodule, and thus new bone of the reactive type can be excluded.

whether anterior or lateral views be taken, only a single border of the bone is usually involved. The region affected is most frequently one of four favorite sites: the medial side of the lower femur at the adductor

ways presents an indefinite and infiltrating edge at its apex. Most of the extra-cortical tumor mass extends under the periosteum, working its way along the shaft, but the point of maximum growth is not encapsu-

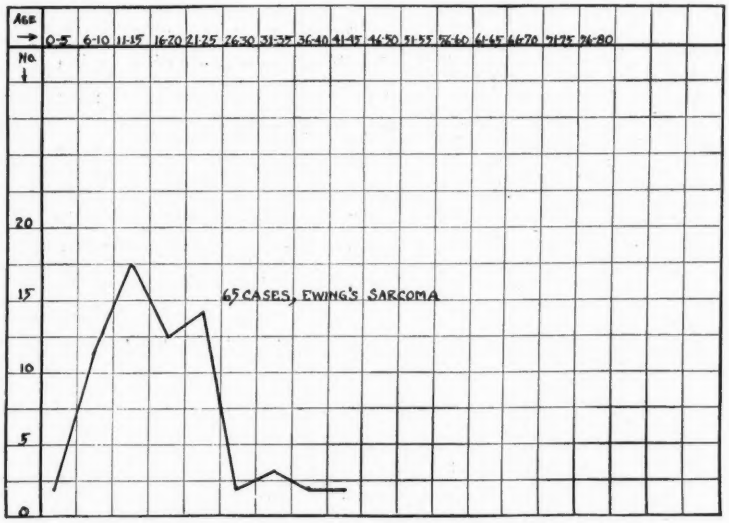


Fig. 12. Chart showing the age incidence of Ewing's sarcoma.

tubercle, the inner aspect of the tibial tuberosity, the margins of the pelvis, or about the greater tuberosity of the humerus. When new bone of tumor origin is present the formation is always sparse, and takes the form of finely radiating lines at the base of the tumor shadow next the bone. Lines of calcification may interlace among the soft-part shadow to give it a loose, soap-bubble effect (Figs. 8 and 9).

Much diagnostic help is gained by comparing the inner margin of the tumor which borders on cortical bone with the peripheral portion extending into the soft parts. The inner margin is most often formed by smooth and normal cortex, although rarely, in later stages, the layers of the cortex may be split and invaded by tumor which finds its way into the marrow cavity. Outwardly, on the other hand, the tumor allated by this structure. The absence of periosteum at this point is explained by the normal anatomical peculiarities of the tumor site, for at these points there is to be found a direct union of tendon to bone without an intervening periosteum.

The basis for the clinical and roentgenologic difference between these two forms of periosteal sarcoma is fundamentally grounded in the separate histogenesis of the two tumors (Figs. 10 and 11). The chondrosarcoma, often referred to as chondromyxosarcoma, arises in an embryonal form of periosteal connective tissue, known to embryologists as the extra-skeletal blastema and to pathologists as myxoma. This extra-skeletal tissue in the embryo forms joints and peri-articular structures, including the bony ends of the tendons and ligaments, particu'arly the ends of tendons

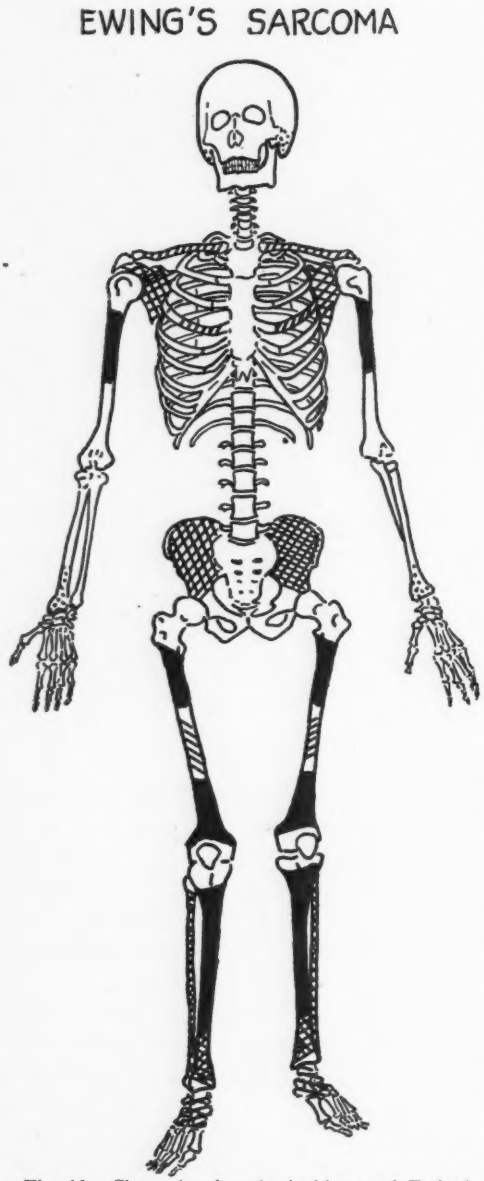


Fig. 13. Chart showing the incidence of Ewing's tumor according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occassional sites, and the dotted areas, the rare sites.

uniting directly to bone such as the quadriceps tendon, adductor magnus, Achilles, etc. It is in reality a pre-cartilaginous tissue, although in the region of the joints it can undergo regressive changes, producing synovial spaces, such as the joints and bursæ. The site of origin of chondrosarcoma, therefore, is either truly periosteal or extraskeletal, and these tumors may arise some distance from the bone in a cartilaginous center of a tendon (2). Histogenetically, these tumors are closely related to the osteochondromas, a point which will be emphasized farther under the heading of Myxosarcoma *(which see)*. The bulk of the tumor is either precartilaginous (myxomatous) or cartilaginous and therefore translucent or nearly invisible in the X-ray film. Only by invasion of the underlying cortex of the bone does this tumor stimulate a small amount of new bone reaction, or, when invading the bone marrow, produce medullary bone destruction.

The osteoblastic form of osteogenic sarcoma, on the other hand, arises in the subperiosteal osteogenic layers of the bone, from the primitive layers of periosteum next the cortex which are capable of direct membranous bone formation. This osteogenic layer of the periosteum ceases at the epiphyseal line in patients over three and one-half years of age, and also decreases steadily in proliferative powers after birth at the mid-shaft region, where ossification is complete early in life. This accounts for the predominant metaphyseal site of these growths. Since the tissue of origin and the area involved are primarily osteogenic in nature, the result on the X-ray film as well as microscopically is a tumor predominated by new bone formation. The bone-forming cells of the tumor readily permeate the haversian canals, producing the sclerosing of the marrow cavity so important from the standpoint of X-ray diagnosis.

If the histogenic distinction between these two forms of periosteal osteogenic sarcoma is borne in mind, the differentiation may be made between them in the roentgenogram. The chondral form is char-

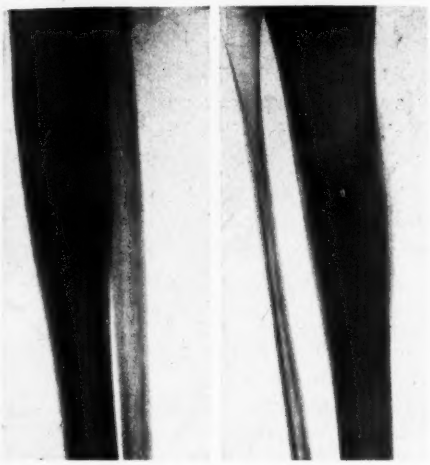


Fig. 14. The typical roentgenologic appearance of Ewing's sarcoma. There is expansion of the shaft of the bone, produced by thickening of the cortex which is reacting to tumor invasion. This is an early stage of the disease.

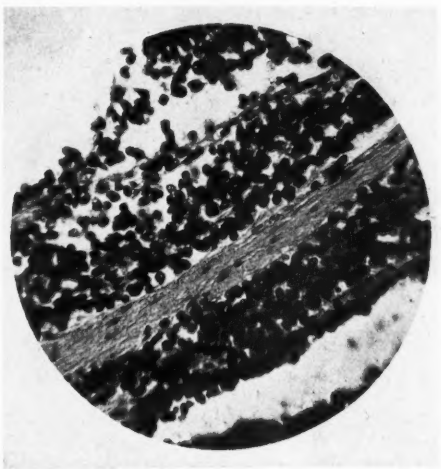


Fig. 15. Photomicrograph showing the uniformity in the size of the cells in Ewing's sarcoma. In the less compact regions the cytoplasm has a definite but irregular outline. There is a typical fibrous strand traversing the cellular areas.

acterized by the translucency of the tumor mass, which is restricted to the periosteal zone, producing cortical and medullary destruction only in the late stages; while the periosteal form is characterized by diffuse dense and shaggy new bone formation, greatest in the periosteal region, but also producing medullary sclerosis early in the disease.

The opportunities for complete cure are not great in even the earliest stages of either type of periosteal osteogenic sarcoma. Deep X-ray therapy may limit local extension of the tumor, but metastases are not inhibited nor is lysis stimulated in the tumor mass. Early amputation when the growth is below the ankle or in the tibia or femur and resection when the fibula or humerus is affected, offers nearly 30 per cent of chances of a cure in the osteoblastic form and about 10 per cent in the chondral form. In this chondral form of sarcoma, radium implantation into the operative wound should be tried, as there is some evidence that this is more effective than X-ray therapy (3, 4).

3. Ewing's sarcoma.—This third type of malignant tumor of the bone is about one-fourth as frequent in occurrence as the periosteal osteogenic sarcomas. It is essentially a disease of early life, 95 per cent of the tumors occurring in the first two decades. Males predominate over females in an approximate ratio of two to one. In the early stages the tumor is always single, but the growth may metastasize to other bones in about one-fourth of the cases. The bones most frequently involved are those of the long pipe class, the tibia and femur leading the list, although the ilium, scapula, clavicle, skull, and bones of the feet are occasionally affected. In the present series of sixty-five cases, in no instance was the primary location of the tumor on other than the shaft side of the bone. Pathologic fracture is of relatively rare occurrence in Ewing's sarcoma—it was noted in only three cases in the series, all of these in the femur, a weight-bearing bone (Figs. 12 and 13).

Either pain or tumor may be the initial symptom in these cases, but both are present in the later stages. The average duration of

symptoms is thirteen and one-half months at the time of clinical observation. Mild fever, leukocytosis of about 15,000 white cells, and enlargement of the regional lymph nodes in about one-third of the cases lead to an erroneous diagnosis of acute osteomyelitis.

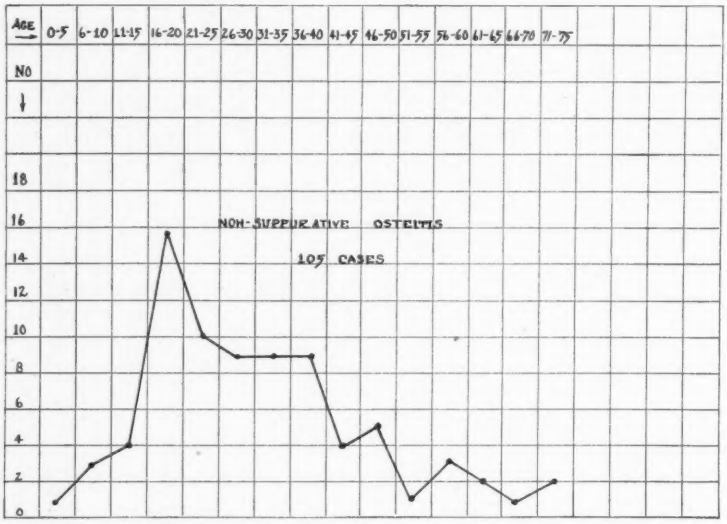


Fig. 16. Chart showing the age incidence of Garré's non-suppurative osteitis.

The first sign of the Ewing tumor in the roentgenogram is a fusiform widening of the shaft, due to parallel layers of subperiosteal new bone formation. Widening of the cortex occurs at this point, with narrowing and even obliteration of the marrow cavity. The current conception that Ewing's sarcoma is a central bone-destructive lesion is erroneous. The site of origin of the growth is subperiosteal and intracortical in the lymphatic channels of the bone, which leads to an early reaction of new bone formation in both the endosteal and periosteal zones. Later in the disease extensive stripping of the periosteum may lead to right-angle new bone formation, while pronounced invasion of the marrow cavity leads to areas of bone destruction (Fig. 14). Splitting of layers of the cortex into the so-called "onion-peel formation" is helpful in making the diagnosis from the X-ray film, but this is usually visible only in the early cases. In the late cases metastasis to other bones, particularly the skull, is one of the striking characteristics of this disease.

The histogenesis of these tumors is valuable in the analysis of the X-ray film. The tumor arises in all probability about the lymphatics of bone in the subperiosteal regions and in the haversian canals (Fig. 15). This mode of origin accounts for both the manner in which the tumor spreads and the early stimulation of reactive new bone. The growth extends beneath the periosteum, giving an elliptical area of involvement, and permeates the haversian spaces, stimulating the cortical bone to reaction. At the age and the site of tumor involvement, bone formation is very active, and hence the widening of the shaft so characteristic in the X-ray film.

The Ewing's sarcoma is definitely radiosensitive and permits, therefore, a therapeutic test in making the diagnosis. Although the best results are generally ob-

tained by radical resection or amputation plus irradiation, some five-year cures have been established by irradiation alone. Proper treatment offers slightly over 10 per cent of chances of cure in this group of tumors (5, 6).

4. Garré's sclerosing osteitis.—Because of a similarity in the roentgenogram to Ewing's sarcoma a summary is included here of Garré's sclerosing osteitis. This condition runs a benign protracted course and in the typical form is much rarer than Ewing's sarcoma. In German clinics it has been estimated that less than 5 per cent of all osteomyelitis is of the Garré type, a conclusion that is borne out by the statistics in this laboratory.[2] The age incidence and the site of bone involvement parallel closely the Ewing's sarcoma, as will be seen in the charts (Figs. 16 and 17). Practically all of the cases occur before the age of twenty-five. The lesion is solitary in character and most frequently affects the tibia, which is involved in slightly over half of the cases. The clinical course of Garré's osteitis, however, is the reverse of that in Ewing's tumor. Whereas in Ewing's sarcoma the disease begins mildly, but rapidly produces acute symptoms within the space of a few months, in sclerosing osteitis there is often an acute onset, with fever and leukocytosis, which rapidly subsides into a chronic course extending over a period of not months but years. The pain is not severe but may be aggravated by exertion and is often worse at nights. Some previous systemic infection such as pneumonia, influenza, or typhoid may be recorded in the history.

In the roentgenogram the area of tumefaction may closely resemble the early stages of Ewing's sarcoma. A fusiform widening of the shaft is produced in the affected region by the stimulation of new bone formation in the periosteal and cortical zones (Fig. 18). As a result of this reaction, the medullary cavity is narrowed or obliterated, while the cortex is thickened and its density much increased. Ossification is more pro-

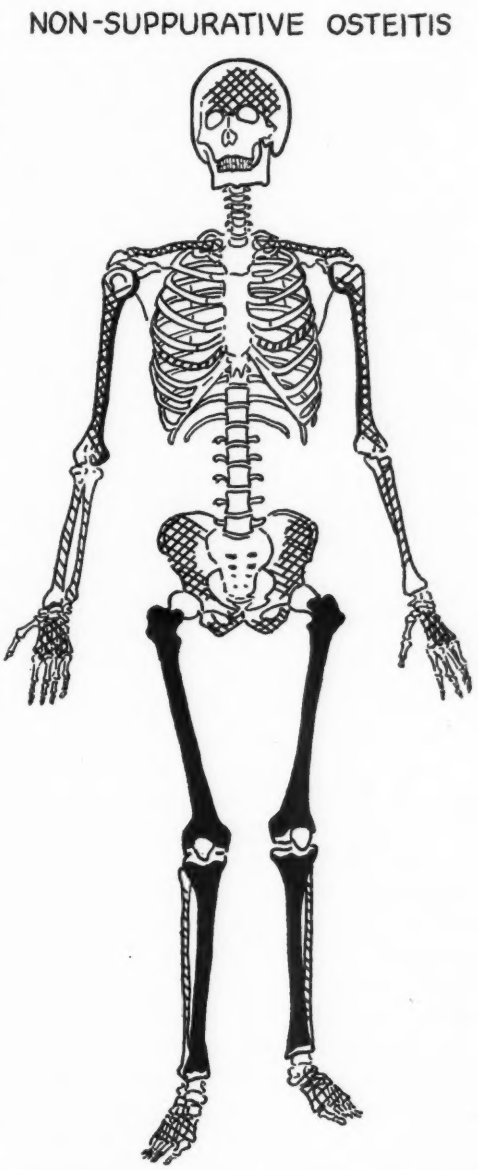


Fig. 17. Chart showing the incidence of Garré's non-suppurative osteitis according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

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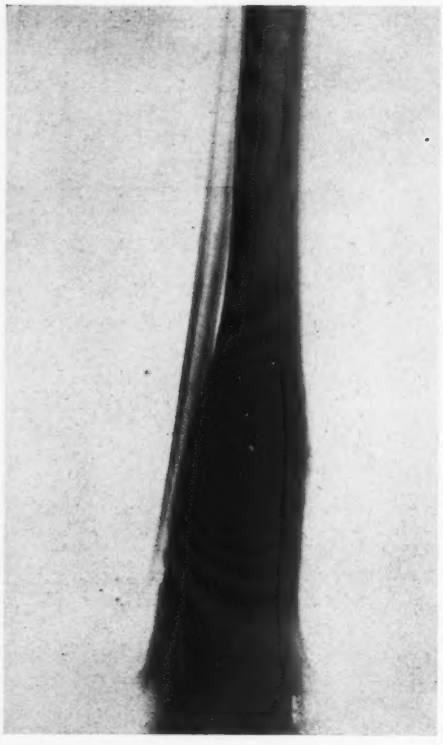


Fig. 18. Roentgenogram of the lower tibia of a patient with Garré's osteitis. There is a diffuse ossifying lesion of the shaft with sclerosis of cortical and cancellous bone and roughening of the periosteum. Note the spindle-shaped swelling produced by the widening of the shaft.

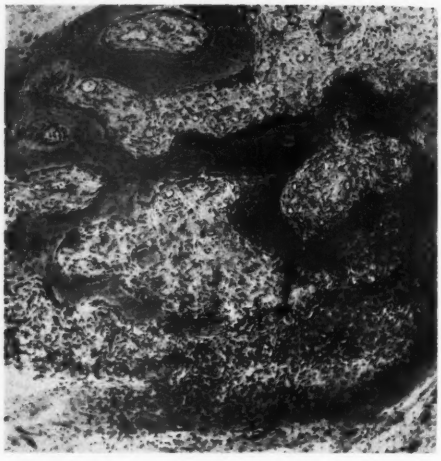


Fig. 19. Photomicrograph showing new bone formation in granulation tissue, illustrating the typical pathologic changes seen in Garré's non-suppurating osteitis.

nounced than in a Ewing's sarcoma and the "onion-peel formation" in the periosteum, typical of the Ewing's tumor, is lacking.

The pathology of Garré's osteitis explains its close similarity in the roentgenogram to the early Ewing's tumor. Sclerosing osteitis is the result of a low-grade infection in the lymphatics of the bone (Fig. 19), which brings about an increased fibrous and fibro-osseous proliferation, resulting in thickening of the periosteum and diminishing vascularity in the regions affected. As in the Ewing tumor, the lymphatic involvement coincides in location with the locus of osteogenic tissue, which is particularly active at the age period when these lesions occur. New bone formation in the endosteal and periosteal layers of the bone is thus secondary to the neighboring lymphatic invasion.

The prognosis in Garré's osteitis is always favorable for life, although the treatment is not uniformly satisfactory. Drainage into the cortical area of the bone by multiple drill holes or by the chiselling of a groove, stimulates vascularity and may result in cure. Diathermy or the application of heat by other methods without surgical intervention may be equally effective, but a definite percentage of the cases are refractory to any method of treatment. Deep X-ray therapy should be tried first in these cases (7, 8).

Summary of solitary osteoplastic lesions in patients under twenty.—Four lesions have been grouped under the solitary ossifying tumors occurring in patients under twenty. These are the exostosis, periosteal osteogenic sarcoma, Ewing's sarcoma, and Garré's osteomyelitis. The most common of these lesions are benign exostosis and the malig-

nant osteogenic sarcoma. Ewing's sarcoma is relatively rare and Garré's sclerosing osteomyelitis still rarer. Exostosis and osteogenic sarcoma are usually localized growths concentrated at a single point in the

tic form of osteogenic sarcoma produces from the first sclerosing and mottling in the marrow cavity. In Ewing's sarcoma, the medullary cavity is narrowed and later perforated by bone destruction. In Garré's os-

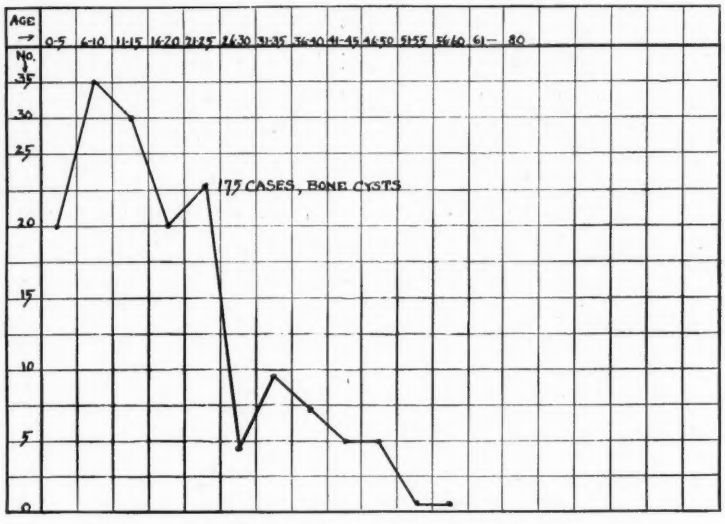


Fig. 20. Chart showing the incidence of benign bone cysts.

periosteal zone. The new bone formation projects at right-angles to the shaft—in the exostosis in the form of an orderly organized pedicle or base of normal bone, in osteogenic sarcoma in a disorderly fashion of radiating spicules of tumor bone. The new bone formation in Ewing's sarcoma and Garré's osteomyelitis extends in a parallel fashion along nearly one-half of the extent of the shaft. There is thus produced a diffuse fusiform widening of the shaft at the site of the involvement, due to periosteal bone formation, while endosteal bone formation in the same region thickens the cortex inwardly, tending to obliterate the marrow cavity. The medullary cavity is practically never involved by an exostosis. The chondral form of osteogenic sarcoma rarely disturbs it except with areas of bone destruction late in the disease. The osteoblas-

teomyelitis the medullary cavity is narrowed or obscured by cortical bone formation, but medullary bone destruction rarely occurs. Pathologic fracture is not frequent in any of these lesions.

II.—Solitary Osteolytic Tumors Prevalent in Patients under Twenty

In young patients a single bone-destructive lesion is usually medullary in character. Both benign and malignant tumors of this type occur, but by far the most frequent is the benign solitary bone cyst. In rare instances the bone cyst may be simulated by a focus of infection in the medullary cavity, the Brodie's abscess. Osteolytic sarcoma of the bone may also resemble the bone cyst, but most frequently produces far more destruction in all of the bone layers. These three groups of lesions, the bone cyst, osteo-

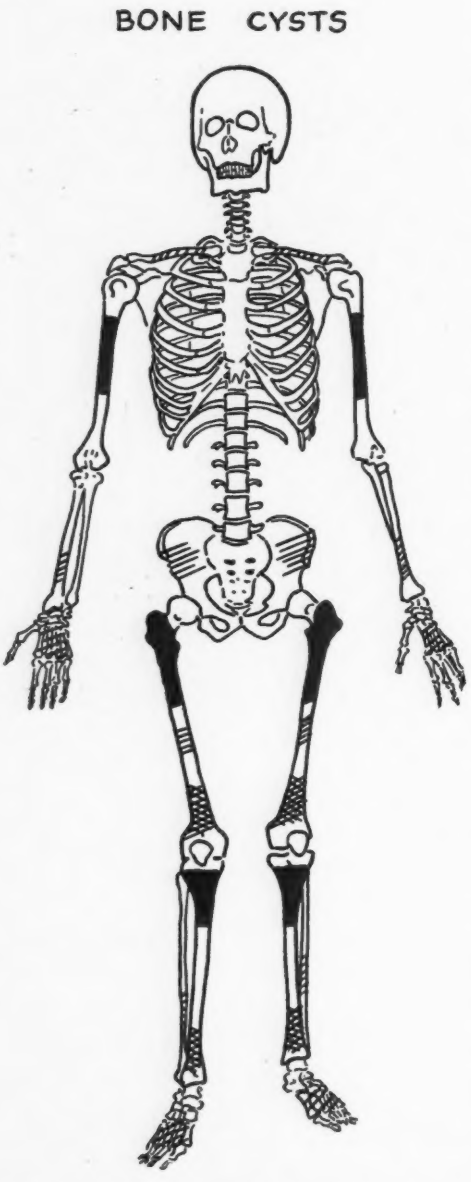


Fig. 21. Chart showing the incidence of bone cysts according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

lytic sarcoma, and Brodie's abscess will be considered separately.

1. Bone cyst.—The solitary bone cyst is a form of osteitis fibrosa found usually in the metaphyseal region of the shafts of the long bones of young patients. The average age is between ten and fifteen years and the usual location is the upper humerus, upper tibia, or upper femur (Figs. 20 and 21). The patient often comes under observation because of trauma, with pathologic fracture, the symptoms of the disease in other cases being very mild, with slight or no pain. The disease runs a benign and chronic course, the duration of symptoms at the time of clinical observation averaging two and one-half years. In about one-sixth of the cases the tumor persists unobserved for over five years, and when it is discovered it has migrated toward the mid-shaft region, due to the growth of the bone. This group constitutes the so-called latent bone cysts which may occur in patients of any age and is discussed separately in a subsequent section.

X-ray examination of these tumors reveals an ununited epiphysis near the diseased area, the metaphyseal location of the lesion, and a central area of bone destruction casting little or no shadow. About the area of bone destruction the cortex is thin and expanded to form a symmetrical and fusiform swelling. In cases in which pathologic fracture has occurred the margins of the fracture show new bone formation, casting a dense shadow. Such a fracture tends to heal, and in the process of healing the lesion frequently ossifies and disappears. The bone shell about the cyst is rarely perforated except by fracture (Fig. 22). The cystic area of the tumor may be crossed by lines of trabeculation, and the shaft of the bone may be bent or otherwise distorted in the affected region.

At the age and in the location in which the tumors occur there is a relationship to an unossified epiphyseal line. The bone involved is, therefore, an area of bone newly derived from cartilage in a metaphyseal region, and the pathologic process is related to this new bone formation. In a histologic

study such a relationship can be definitely traced (Figs. 23 and 24). Early bone cysts always show areas of giant-cell tissue and this tissue is the cause of the bone destruction which produces the cyst. These giant cells normally play an active rôle in resorbing calcified cartilage in the transition from cartilage to new bone which occurs in the metaphyseal region. Cyst formation is the result of a pathologic overactivity on the part of these giant cells, due to trauma or some metabolic disturbance. By the time most of these lesions come under observation or come to operation, the bone destructive phase has ceased and a second process of new bone formation about the periphery of the tumor, due to the proliferative powers of the neighboring cortex and the subperiosteal osteogenic layers, has occurred, which succeeds in walling-in the diseased area, and may, when pathologic fracture has occurred, entirely heal the area. The prognosis is uniformly favorable in these tumors and cure can be effected by the curetting and crushing of the cavity, or often by X-ray therapy (9, 10).

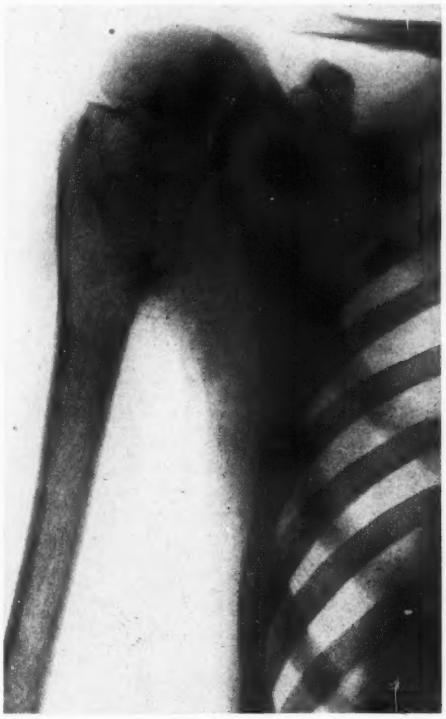


Fig. 22. A typical bone cyst in the upper end of the humerus showing ossification and healing after fracture. The following characteristics are illustrated: The cyst is on the shaft side of an unossified epiphyseal line, the cortex about the cyst is thinned and symmetrically expanded, and there is ossification after fracture.

2. Osteogenic sarcoma of the osteolytic type.—Two relatively rare forms of osteogenic sarcoma are prone to produce bone destruction in the medullary region of the long bones: the more frequent of the two is a fibro-osseous form of tumor; the rarer is cartilaginous in nature. The fibro-osseous type of osteolytic sarcoma constitutes about 20 per cent of sarcoma of bone, while the cartilaginous form comprises approximately 5 per cent. In both forms, males predominate over females and the age incidence is maximal between the ages of ten and twenty, as is usual for all sarcomas of bone (Fig. 25). In the fibro-osseous form of osteolytic sarcoma, however, there is a larger percentage of cases occurring after the age of thirty (approximately 33 per cent). Despite the fact that both of these sarcomas of bone are medullary and bone-destructive, their fundamental histologic difference is reflected in both the clinical and X-ray pictures.

The fibro-osseous form of osteolytic sarcoma has a distribution which involves the shaft of the bone towards its middle or in its metaphyseal region. The upper tibia, lower femur, and upper humerus are most frequently affected (Figs. 26-*A* and 26-*B*). The average duration of the symptoms is ten months, and pain, tumor, and pathologic fracture are outstanding features, pathologic fracture occurring in 35 per cent of the cases. In the X-ray film the area of bone involvement shows a worm-eaten area of medullary bone destruction without any defi-

nitely circumscribed margin and without new bone formation. The cortex of the bone is rapidly broken through without expansion, a point which differentiates these lesions from the benign bone cysts (Fig. 27). The configuration of the lesions may resemble metastatic carcinoma to bone, but in this form of sarcoma the patient is usually younger and the tumor area, which begins subcortically, breaks through the cortex before it assumes the truly central medullary location typical of metastatic carcinoma. The transition between destroyed bone and healthy bone is apt to be more abrupt in this sarcoma than in metastatic carcinoma.

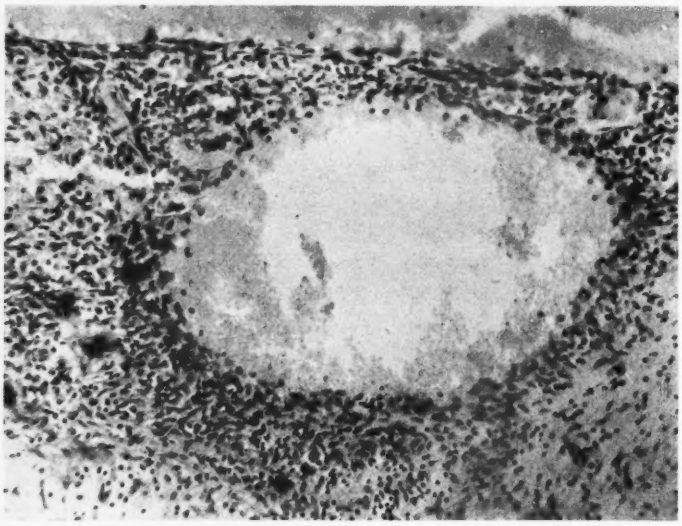


Fig. 23. Photomicrograph showing a newly formed cyst containing red blood cells and surrounded by a sprinkling of giant cells. This is the early stage of osteitis fibrosa. Compare with Figure 24.

Histogenically these tumors arise from fibrous tissue capable of direct bone formation embedded in the medullary cavity (Fig. 28). Bone formation, which in this tissue is dependent upon previous calcifying of cartilage, does not occur, because such cartilage is lacking at the age when and the site where these tumors arise. The prognosis in this form of sarcoma of bone is not so bad as in the chondral forms. In the series of eighty-seven cases in this group, sixty-three have been followed over five years since treatment, and seven (or 11 per cent) are living. The earliest and most radical operative treatment gives the best results.

The chondroblastic form of osteolytic sarcoma usually involves the upper tibia, upper humerus, and lower femur. It produces an area of bone destruction which borders directly on the epiphyseal line, in patients practically always between the ages of fourteen and twenty. The average duration of symptoms is exceedingly brief, being under four months, and the post-operative duration of life rarely exceeds twenty months. Pain and swelling are present in an acute form, but pathologic fracture is not frequent.

In the X-ray film the typical picture of the chondral form of osteolytic sarcoma of bone is a circumscribed or diffuse area of medullary bone destruction occurring on either

side of the epiphyseal line. The cortex and the periosteal zone show a more variable involvement. In advanced stages, when the medullary destruction resembles that seen in Figure 29, the cortex may be expanded and thinned as in a typical giant-cell tumor, the location in the epiphysis making the similarity even greater. However, there is usually periosteal elevation, with an underlying translucent shadow, which distinguishes these tumors from benign giant-cell tumors and makes them more comparable to the advanced stage of the periosteal chondrosarcoma described previously. While this is a separate form of osteogenic sarcoma which histologically can be shown to arise from the proliferating cartilage cells at the epiphyseal line, during the adolescent growth period (Fig. 30), and while the mode of growth is distinct—producing, first, medullary bone destruction near or in the epiphysis, and later cortical or periosteal involvement—still the X-ray picture at the time of clinical examination may be indistinctive and cannot, as a general rule, be distinguished with any degree of accuracy from other forms of osteogenic sarcoma. The usual mistake of diagnosing this as a benign giant-cell tumor can be avoided, however, if one notes that the tumor involves usually both the epiphysis and the metaphysis and produces a definite periosteal lipping.

This is one of the most malignant tumors of the osteogenic sarcoma group and there are only two patients living over five years among the twenty cases which have been followed clinically since operation. Radical surgery followed by post-operative irradiation appears to offer the only hope in patients thus afflicted. Irradiation is best given by radium implantation (11, 12).

3. Brodie's abscess.—One hundred years have elapsed since Brodie first described this rare clinical entity of bone, which is characterized by a small single area of medullary bone destruction due to a latent chronic infection in the cancellous tissue at the extremity of a long bone. Males are affected far more frequently than females (five to ten times in most of the series recorded), and the predominate period of life is in the decade falling between the ages of fourteen and twenty-four years (Fig. 31). More than half of all cases reported in the literature[3] have been located in the tibia, the major portion of the remaining affecting the lower femur and lower humerus.

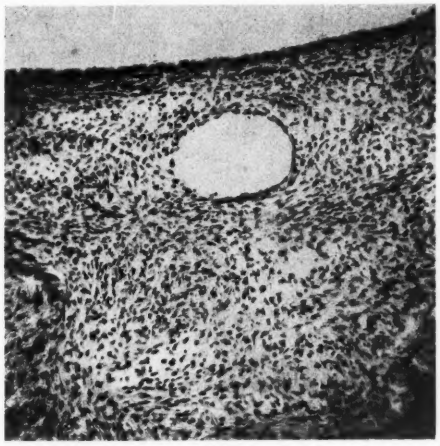


Fig. 24. A late stage in osteitis fibrosa, showing the condensation of fibrous tissue in the wall of a large cyst. A small cyst is also shown. Compare with Figure 23.

The duration and clinical symptomatology reflect the etiology of the disease. In a large percentage of the cases (84 per cent in Thomson's series[4]) there is a previous history of acute osteomyelitis. Students of this condition are agreed that cases of acute osteomyelitis may develop such a Brodie's abscess as a residual or complicating feature. This emphasizes the fact that contrary to a commonly erroneous conception, Brodie's abscess is not of tuberculous origin, but is most frequently dependent upon the presence of a staphylococcus infection of low virulence. Many of the patients give a history of an

[3]M. S. Henderson and H. E. Simon: Brodie's Abscess, Arch. Surg., November, 1924, IX, 504 (Pt. 1).

[4]Thompson: Edinburgh Med. Jour., 1906, XIX, 297.

acute and septic onset, which rapidly subsides, to be followed during the period of the next months or years by variable and usually mild pains in the affected region. In addition to this protracted history, there is roentgenologist. Pathologic fracture is extremely rare in these lesions and has never been recorded in our series.

Pathologically the diseased area takes the form of a small island of soft granular ma-

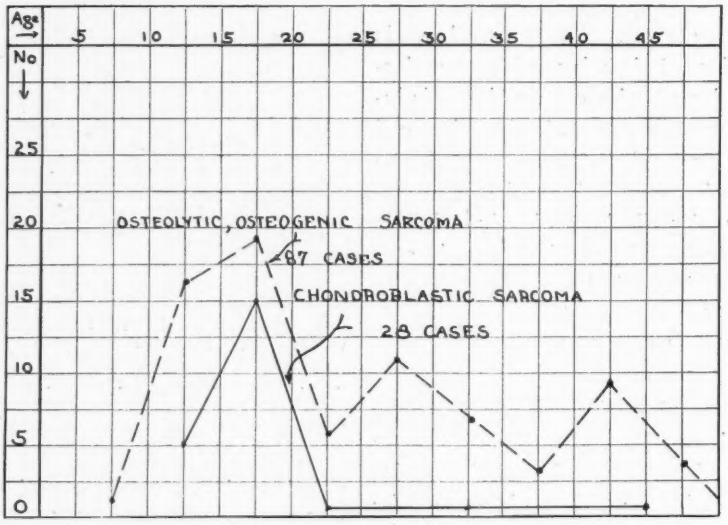
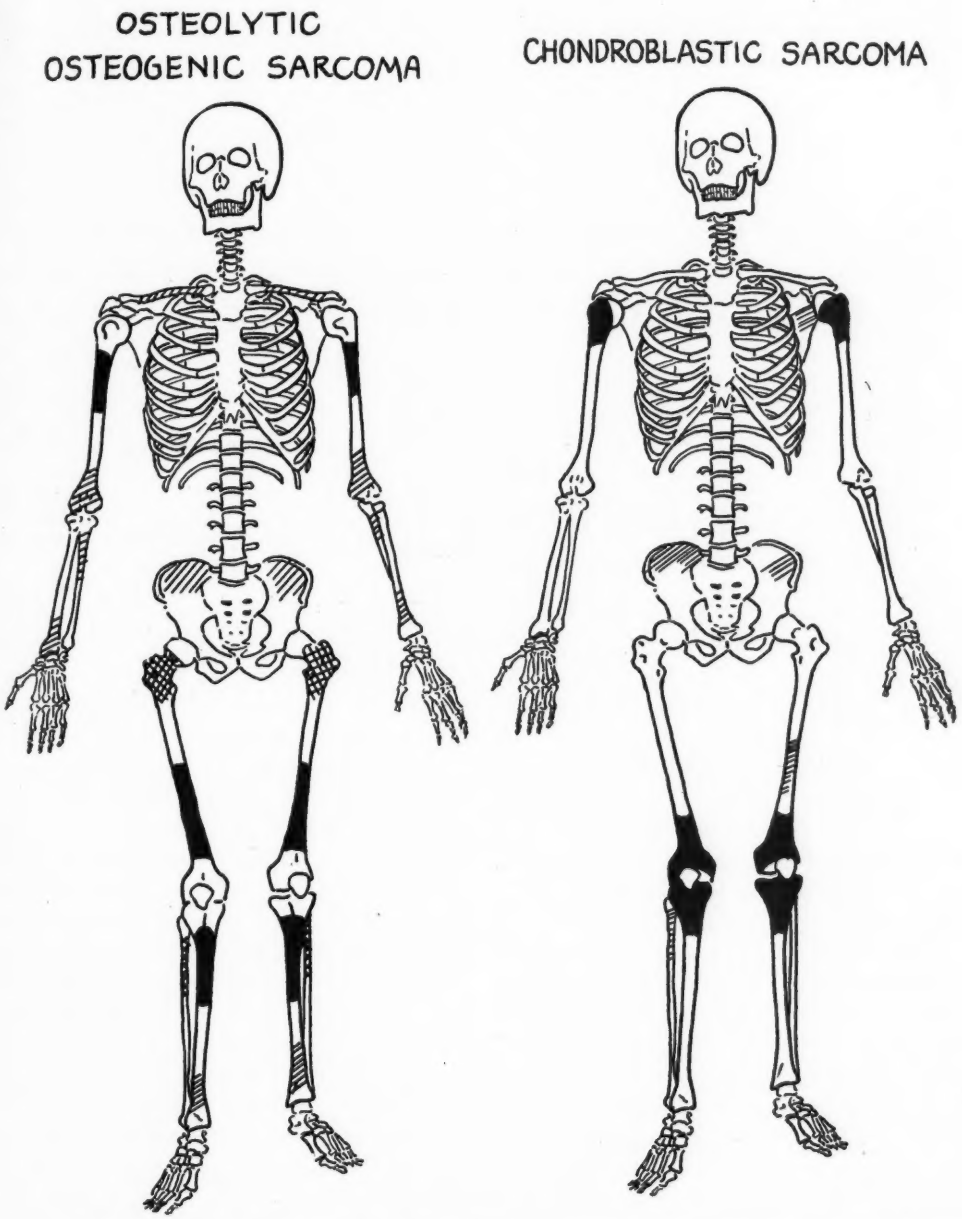


Fig. 25. Chart showing age incidence of two forms of osteolytic sarcoma. The solid line indicates chondroblastic sarcoma, and the broken line, osteolytic osteogenic sarcoma.

a fusiform swelling of the bone in the upper or lower tibia to aid in making the diagnosis clinically.

In the X-ray film the involved bone shows a more or less circular, rarefied area in a central location in the metaphyseal region of a long bone, usually the upper or lower tibia. The cortical bone about the lesion shows increase in density and expansion, which produces a definite and palpable swelling. Such a Brodie's abscess may be distinguished from a bone cyst because the involved area is considerably smaller, usually from one to two centimeters in diameter, and the neighboring cortical bone is practically always far thicker than that found in the bone cyst (Figs. 32-*A* and 32-*B*). Occasionally the area of bone destruction may be so small that it is overlooked by the terial in the medullary cavity or the small cavity filled with fluid: about this there is usually an area of increased density. The origin of the disease is due to a dormant focus of infection, carried to the medulla of the bone by the blood stream and remaining quiescent until the resistance of the patient is lowered by a general systemic disease or locally by trauma to the infected bone. The mode of infection differs from that of Garré's osteitis, which is *via* the lymphatics. Unlike acute osteomyelitis, high fever and leukocytosis are rare, but occasionally sinus formation and a sequestrum may occur. A good prognosis may be given if proper surgical evacuation of the infected area is performed (13, 14).

Summary of osteolytic lesions in patients under twenty.—In the differential diagnosis



Figs. 26-*A* and 26-*B*. Charts showing the incidence of osteolytic osteogenic sarcoma (26-*A*) and chondroblastic sarcoma (26-*B*) according to skeletal locations. The solid black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

of these three lesions—the bone cyst, the osteolytic sarcoma, and Brodie's abscess—the most helpful consideration is the condition of the cortical bone in the neighborhood of the lesion. In the bone cyst the area of bone destruction is immediately beneath the cor-

Fig. 27. Roentgenogram showing the destructive rotten-wood appearance in a long bone, the seat of osteolytic osteogenic sarcoma. The cortex has been broken through without expansion and a soft-part tumor has been produced.

tex and expands the cortical bone, which is thinned but bulges symmetrically on either side of the lesion, remaining intact unless pathologic fracture occurs. In Brodie's abscess the area of bone destruction is some distance from the cortex and the cortical bone is thickened rather than thinned, the swelling in this region being due to this thickening rather than to bulging or expansion of the cortex. In osteolytic sarcoma of the fibro-osseous type the area of bone destruction extends directly through the cortex, which early in the disease is dissolved away, along with the medullary bone. In the chondral form of osteolytic sarcoma the

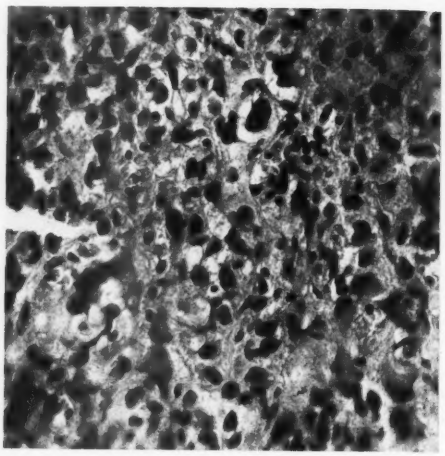


Fig. 28. Photomicrograph of an osteolytic type of osteogenic sarcoma, showing the large vesicular nuclei and mitotic figures common to this type of sarcoma.

cortex may survive longer and may be thinned and expanded, but evidence that the tumor has passed beyond is visible by periosteal lipping, roughening, or by the actual presence of the translucent tumor mass in the periosteal zone.

The configuration of the area of bone destruction is also helpful in roentgenologic diagnosis. In Brodie's abscess the rarefaction is small and sharply circumscribed. In the bone cyst it is larger, may be oval or more irregular, but is definitely limited by a bone shell in all directions. In osteolytic sarcoma of the fibro-osseous type the area of bone destruction is exceedingly irregular and worm-eaten, with jagged margins extending in different directions. In the chondral form of osteolytic sarcoma the area of bone destruction is more often multiloculated and usually fades off, with a hazy margin.

III.—Myxosarcoma and Pyogenic and Specific Infections of Bone

The clinical entity known as myxoma or myxosarcoma and a group of infections of

the bone warrant separate discussion at this point, since these entities do not fall readily into line with the basis of classification used for the other lesions treated in this paper, because all of them are capable of showing in the X-ray film both bone formation and bone destruction.

1. Myxosarcoma of bone.—Myxoma of bone, which was described as a separate form of bone tumor by Bloodgood (16), is potentially a malignant neoplasm and in the light of more recent studies is more properly classed as a secondary form of malignancy arising at the site of a previous benign osteochondroma. In the final stages the growth is histologically indistinguishable from the chondral form of osteogenic sarcoma (the so-called chondromyxosarcoma), but clinically its course is far more protracted and is unique among the sarcomas of bone. The patients with such a lesion are adults over thirty years of age and are often unaware of a pre-existing exostosis or chondroma. Usually a history is obtained of rheumatic pains, extending back over a number of years (two to twenty), referable to the region of the tumor. Exacerbation of the symptoms such as severe pain or increase in swelling, brings the patient under observation. The degree of malignant change and the grade of the malignancy may vary greatly in such a lesion, and it is difficult to predict from either the X-ray film or the miscroscopic appearance the course of the disease if radical surgery is not instituted (Figs. 33-*A* and 33-*B*).

In the X-ray films the discovery of the remnant of the earlier benign osteochondroma may be relatively easy or exceedingly difficult. If the malignant change is early, the cartilaginous cap of the tumor may be seen invading the base of the exostosis and encroaching upon the medullary cavity. If the growth is more advanced, the previous ossification in the osteochondroma may be scattered as granular débris in the enlarging translucent tumor mass and nothing of the original exostosis may remain except the congenital defect of the widened metaphysis (Figs. 34-*A*, 34-*B*, 34-*C*).

Fig. 29. Roentgenogram of a chondroblastic sarcoma in the upper end of the humerus. The tumor has the typical multilocular formation of a cartilaginous lesion and the periosteal reaction of a sarcoma. The area of bone destruction is located at an epiphyseal line, extending into both the epiphysis and the shaft.

If the lesion is treated by local excision, it may recur repeatedly. In not a few instances such tumors have recurred as many as from five to fifteen times following repeated cauterization over a period of six to eight years, eventually ending in a complete destruction of bone at the tumor site and the death of the patient from pulmonary metastasis. Apparently the best mode of treatment of such lesions when the histology is that of an outspoken chondromyxosarcoma (Fig. 35) is by radical resection, or amputation when possible.

2. Osteomyelitis, tuberculosis, and syphilis of bone.—These three entities of

osteomyelitis, tuberculosis, and syphilis are mentioned here more for the purpose of ruling them out of the discussion of the differential diagnosis of bone tumors by the X-ray, than for the purpose of detailed consideration. The diagnosis of all three of these conditions depends primarily upon the clinical picture rather than upon the X-ray.

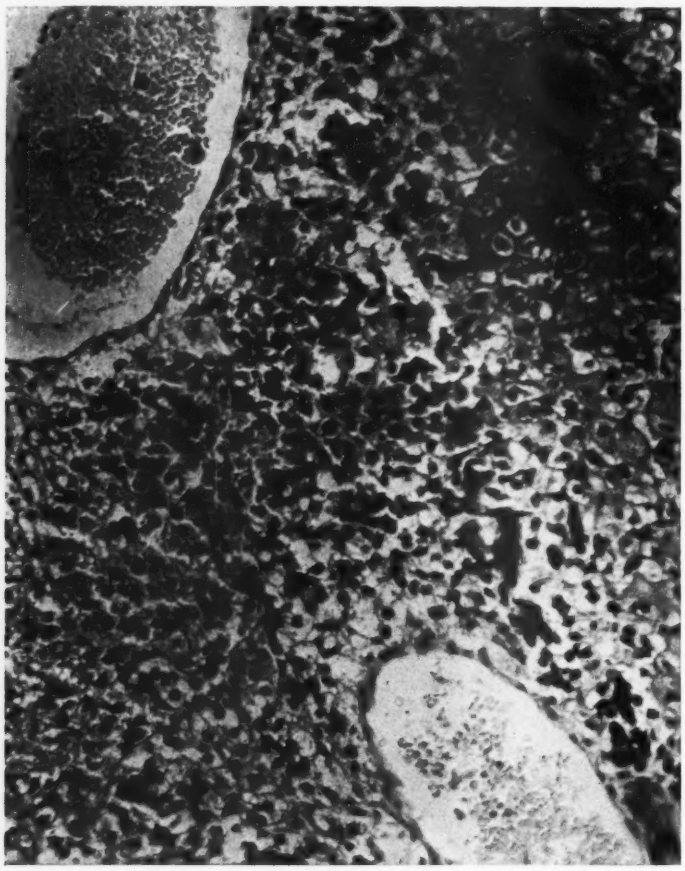


Fig. 30. Photomicrograph showing the chondroblasts, the cartilage, and the abortive calcification in a chondroblastic sarcoma. The capillaries in the illustration indicate the vascularity of this sarcoma.

In a child between the ages of two and ten years, the occurrence of high fever (103-104°), leukocytosis (25,000-30,000), and a toxicity indicative of an acute infection, plus localized pain and point tenderness near the epiphyseal line of a long bone, without involvement of the neighboring joint, is ample presumptive evidence for the diagnosis of an acute osteomyelitis. Exploration by the surgeon should follow, and confirmation by X-ray examination, which is negative at this stage of the disease, should not be awaited.

The X-ray picture of an acute osteomyelitis is characteristic only when surgical intervention is delayed. At this stage there is generally evidence of bone destruction and new bone formation. The bone affected is

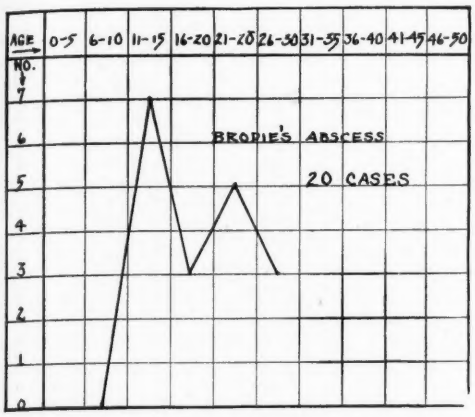


Fig. 31-*A*. Chart showing the age incidence of Brodie's abscess.

typically that of a child under ten and the area of involvement is most frequently in the upper end of the tibia, the lower end of the femur, the lower ends of tibia and fibula, the upper end of the humerus, or the lower end of the radius. As Starr has stated, the area of involvement is generally triangular (Figs. 36-*A* and 36-*B*), with the base toward the epiphysis and the necrotic areas sloping away toward the mid-shaft and toward the periosteum. The periosteum is stripped for some distance by the collection of pus and gives evidence of an involucrum beneath by a dense shadow of new bone formation. Bone destruction, with the formation of sequestrum, is the rule. If the disease become chronic, new bone formation becomes more and more marked and irregular in character. Pathologic fracture may occur.

In tuberculosis of bone, which is also characteristically a juvenile disease, although the local focus of origin is generally in the epiphysis of the bone, the symptomatology and the deformity practically always point to one of the joints, the spine, hip, knee, and ankle being involved in frequency in the order mentioned. Chronicity and deformity are the outstanding features of this disease, the deformity being caused by either

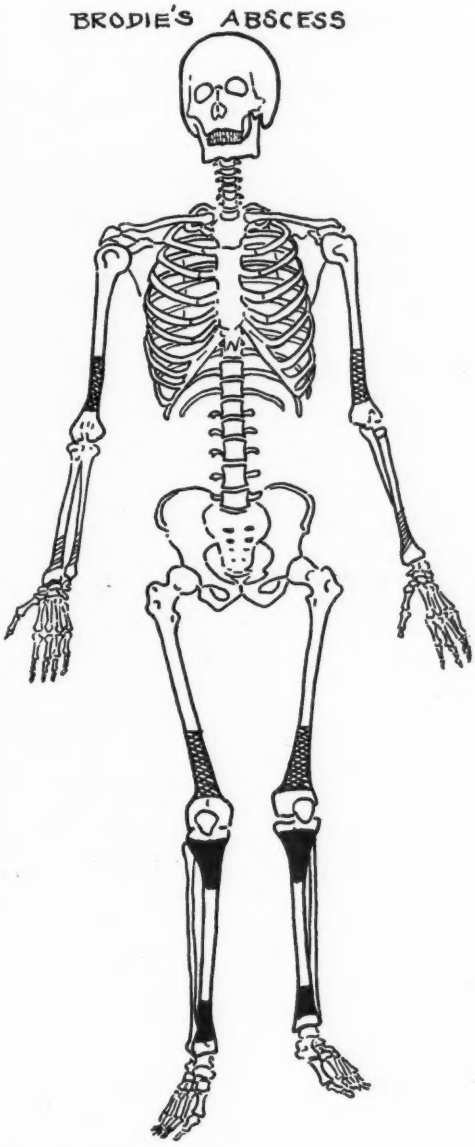


Fig. 31-*B*. Chart showing the skeletal distribution of Brodie's abscess. The black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

muscle spasm, shortening brought about by limitation of bone growth, or actual bone destruction. In the spine, the characteristic deformity is kyphosis in the dorsal region. In the hip, a flexion deformity, with short-

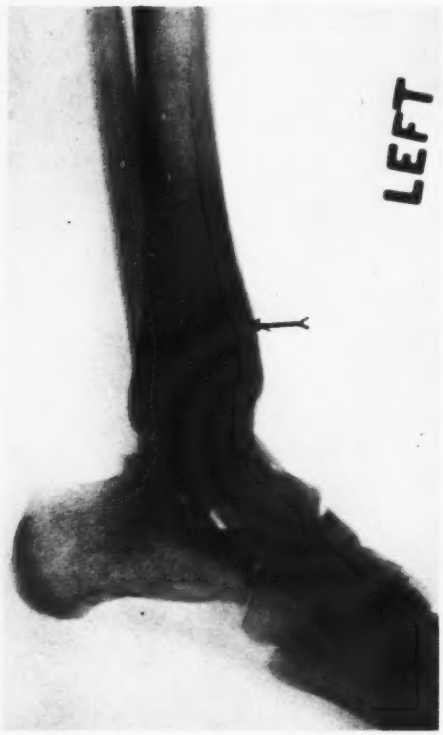


Fig. 32-*A*. Lateral view of a Brodie's abscess situated in the lower end of the tibia. The small size of the bone defect, the periosteal swelling, as well as the location in the tibia are diagnostic. Nearly 90 per cent of all these lesions occur in the long bones.

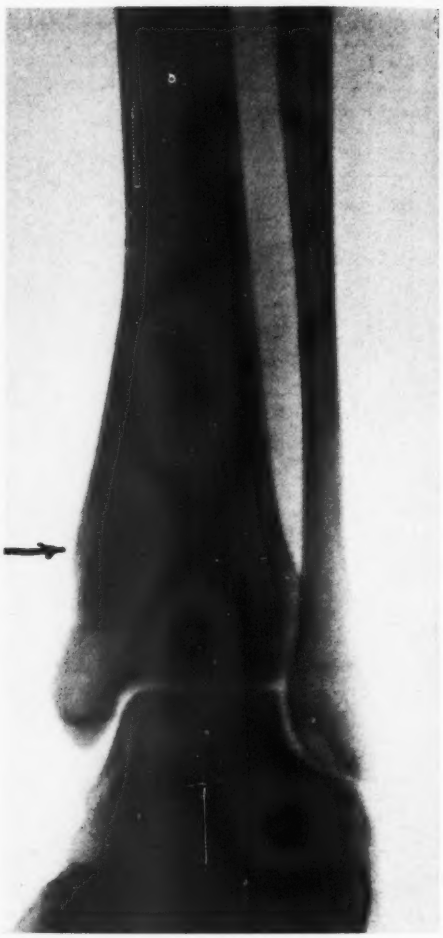


Fig. 32-*B*. Antero-posterior view of same case as shown in Figure 32-*A (which see)*.

ening of the leg, is typical. In the knee, flexion deformity plus the classical white swelling, accentuated by atrophy below, is outstanding, while in the ankle, plantar flexion, with similar swelling, is characteristic. As in osteomyelitis and syphilis, systemic features of the disease play an important part in the diagnosis. The loss of weight, elevation of temperature in the afternoon, and systemic tuberculosis elsewhere in the body aid in making the diagnosis. In addition, the development of a cold abscess or a persistent draining sinus is typical.

In the X-ray examination of tuberculosis, there is seen melting away of the bones to give a diffuse hazing in the region of a joint (Fig. 37). The location in the spine, at the hip, knee, or ankle is also characteristic. Calcified bodies about the bone in the joint or soft parts are not unusual. Subluxation of the bones occurs, while in the late stages synostosis may appear, with healing, although surgical intervention is usually necessary to bring this about. Collapse of the vertebræ and actual dislocation of the hip may occur and some evidence of sinus formation may be visible in the X-ray film.

Syphilis of the bone, which may be congenital in the newborn but which is more

often a disease of adults between the ages of twenty and forty, is a secondary or tertiary phenomenon, although syphilitic periostitis has been described as occurring synchronously with the primary sore or from the typical saber-shin may develop if the case is a congenital one. This is marked by some bowing of the tibia, accentuated by new bone formation, incident to both periostitis and osteitis (Figs. 38-*A*, 38-*B*, 38-*C*).

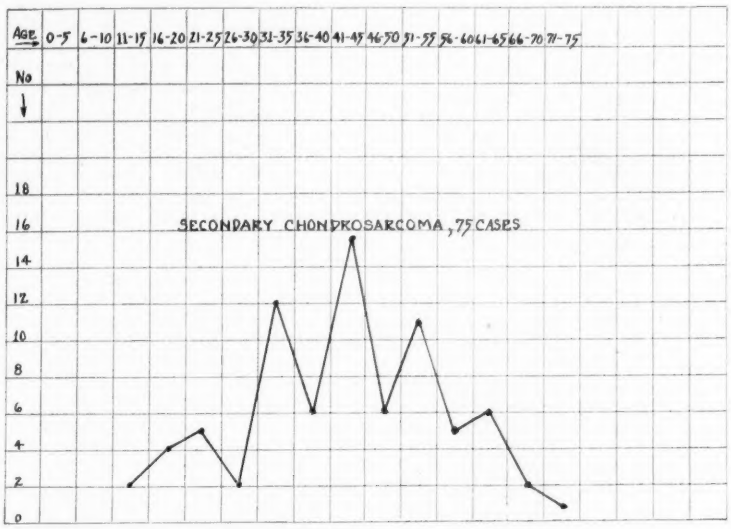


Fig. 33-*A*. Chart showing the age incidence of myxosarcoma or secondary chondrosarcoma of bone.

two to fifteen weeks thereafter. The history of exposure and of a primary sore plus a positive blood Wassermann are essential points in the diagnosis. The osteocopic night pains are helpful but not pathognomonic. Early involvement of the bone is generally restricted to a periostitis, which affects most frequently the cranium, ribs, sternum, and the tibiæ. This periostitis yields readily to anti-syphilitic treatment, restoring the bone to normal, and such a therapeutic test establishes the diagnosis beyond question. In the late stages of bone involvement, gummas are usually present in the affected region, which is most frequently the tibia, and give a nodular character to the bone on palpation.

In the X-ray picture of syphilis which has gone beyond the stage of simple periostitis, Gummatous osteomyelitis in adults leads to an extensive change over a wide area of bone, dependent upon both bone destruction and new bone formation, in which bone destruction generally predominates, producing very irregular bone, with mottling. The bone deformity resembles an ordinary chronic osteomyelitis in these cases, but may be even more severe, with more mottling and irregularity. Pathologic fracture is prone to occur in gummatous osteitis (17, 18, 19, 20.)

IV.—Ossifying Periosteal Lesions in the Adult

While osteogenic sarcoma of the periosteal ossifying type may occur in the latter decades, it is not the usual lesion of this type after the age of twenty. Periosteal fibrosarcoma, however, does occur in pa-

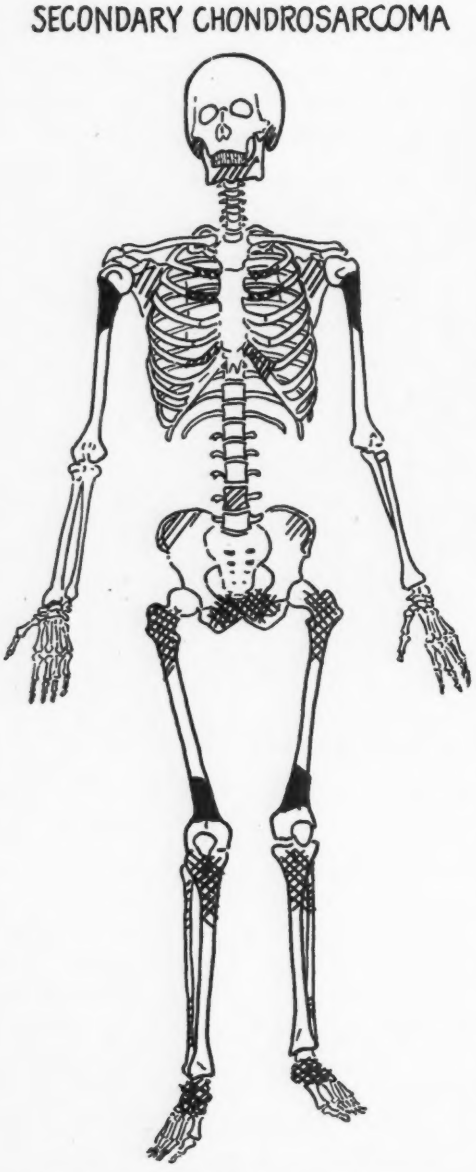


Fig. 33-*B*. Chart showing the skeletal distribution of myxosarcoma or secondary chondrosarcoma of bone. The black areas indicate the most frequent sites; the checked areas, the common sites, and the diagonal line areas, the occasional sites.

Fig. 34-*A*. A case of secondary chondrosarcoma superimposed upon a benign cartilaginous lesion. There is shown here the sarcomatous transformation producing medullary destruction, with pathologic fracture and also a periosteal tumor in the humerus which was the site of a congenital malformation.

tients over thirty, although, strictly speaking, it does not ossify. Myositis ossificans of the traumatic circumscribed type and ossifying periostitis on an inflammatory or traumatic basis, are both diseases of adulthood which may produce ossification in this region of the bone.

1. Periosteal fibrosarcoma.—This is a relatively infrequent sarcoma of bone which affects the fibrous layers of the periosteum, and is, strictly speaking, a fascial sarcoma, since it does not arise from osteogenic tissue. This form of fibrosarcoma is of a relatively low degree of malignancy, nearly one-half of the patients being reported well over a period of from two to ten years after operation. Males and females are affected in about equal proportion. The age of distribution of this tumor is characteristic and very unusual for sarcoma (Fig. 39-*A*). In a series of forty cases, thirty-one are thirty years of age or over. Most of the patients are between thirty and fifty years of age, but a good portion are even older, the oldest patient recorded being seventy-five years. This tumor is typically

a single lesion occurring in the periosteal zone and frequents the usual favorite sites of sarcoma of bone—about the knee in the lower femur and upper tibia (Fig. 39-*B*). The average duration of symptoms is approximately thirty months, and swelling is a more prominent feature than pain.

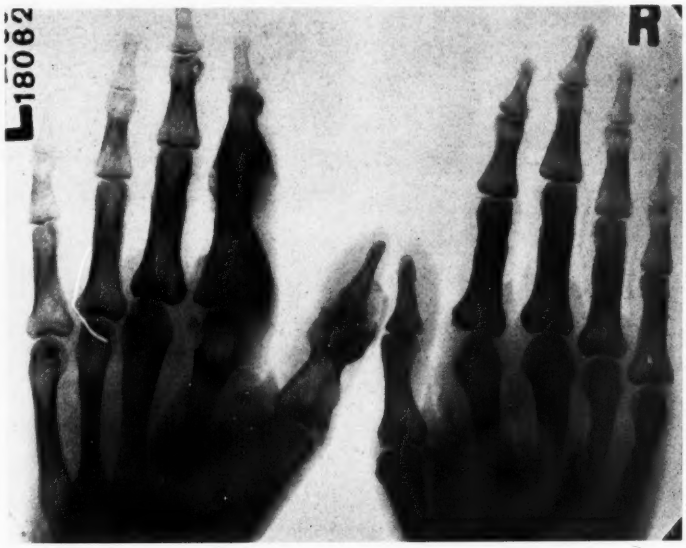


Fig. 34-*B*. Same case as shown in Figure 34-*A*. Here is seen the original nature of the benign chondromatous lesions which also affected the hand.

The X-ray appearance is variable but in most instances is characterized by a cloudy soft-part shadow and secondary bone necrosis. The tumor begins in the periosteal zone, but is unique in extending both outside of and beneath the periosteum. This two-fold mode of growth is explained by the tissue of origin, which is the outermost fibrous layer of the periosteum. The periosteal shadow of the tumor and that extending into the soft parts is visible as a diffuse haze without definite demarcations in the roentgenogram. Rarely there is slight calcification or new bone formation, due to the carrying up into the tumor of small strands of the cambian layer of the periosteum. Beneath this extra-skeletal tumor, the bone is rarefied and resorbed (Fig. 40). Histologically, a definite percentage of these so-called fibrosarcomas of the periosteal type are not sarcomas but fibromas, and this accounts for the large percentage of five-year cures (Figs. 41-*A* and 41-*B*). Fibrosarcoma is to be suspected in the X-ray film when there is a soft-part shadow continuous with the bone of a hazy but not translucent quality, without radiating spicules of bone in the shadow, and when the bone beneath is melted away from without, inward, in an asymmetrical manner. The osteolytic form of osteogenic sarcoma, it will be remembered, destroys the bone from within, arising in the medullary cavity and rarely extending beyond the cortex. The chondromyxosarcoma form of osteogenic sarcoma gives a more translucent periosteal shadow, with small radiating

spicules of new bone, and definitely lifts the periosteum. Such is not the case in fibrosarcoma.

The prognosis in this form of sarcoma depends upon the cellularity of the microscopic structure, and radical treatment, such as amputation, should not be tried unless the pathology is carefully checked by biopsy (21, 22).

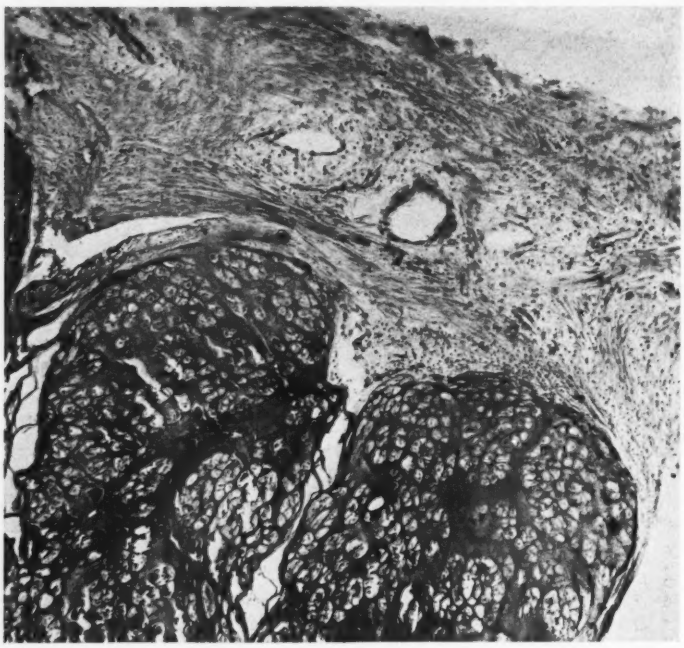


Fig. 34-*C*. Photomicrograph showing the cartilaginous structure of the tumor in the humerus.

2. Myositis ossificans.—Various forms of myositis ossificans have been described. The progressive, diffuse form, which begins in children with other congenital defects, such as microdactylism, and involves successive muscles, beginning usually in the trapezius or latissmus dorsi, is not dealt with here. Varieties of the circumscribed type of myositis ossificans are generally classified under the traumatic and non-traumatic forms, of which the traumatic type is by far the more frequent. The trauma may be single or repeated, due to some occupational habit. The occupational form was the first to be described (Billroth, 1855), under the term "rider's bone," and later under the term "drill bone," both of which are common among enlisted men in the cavalry and infantry, respectively. The ossification of the deltoid muscle, due to the rifle, and of the adductors in the thigh, due to the pressure of the saddle, has been termed the "Prussian disease," since so many of the reports have come from that source (Kuttner[5]).

In this country traumatic myositis ossificans of the circumscribed type is most frequent following a single injury, and is seen most often following posterior dislocation

[5]Kuttner: Die Myositis ossificans circumscripta. Ergebn. d. Chir. v. Orthop., 1910, I, 49-106.

of the elbow producing ossification in the brachialis anticus, and injuries of the quadriceps femoris in foot-ball players. Among the thirty cases of this form of circumscribed myositis ossificans recorded in the Surgical Pathological Laboratory, involvements of these two muscles predominate (Fig. 42). Patients between the ages of twenty and forty are in the majority, the maximum age in this series being forty-three (Fig. 43). Cases occurring under twenty are not rare, but more elderly patients are unusual. Females are very rarely affected—only once in our series. The history is characteristic. Following a severe injury, there is hemorrhage into the muscle, with the formation of a hard tumor, with ossification within a period of from three to six weeks. The injury is commonly received either in foot-ball or accidentally in some occupation, such as mining, mill-working, etc.

In the X-ray film there is a single lesion showing a more or less wedge-shaped area of laminated bone, separated from the normal bone usually by a definite interval of soft parts. The edges are usually smooth and well outlined and the location is commonly near the elbow or in the thigh. Dean Lewis emphasizes a tendency for the area of ossification to attain its maximum rapidly, and then to remain stationary or decrease. The diagnosis of such a lesion by the X-ray, when there is a definite history of trauma, is not difficult. However, variations of this picture occur in which the wedge of new bone may adjoin the shaft of the normal bone beneath, and one free edge may be extremely irregular. The irregular edge, infiltrating the muscles, may assume the characteristic of the so-called dotted-veil, while the fact that new bone occurs only at one side of the normal bone, and does not surround it, is helpful in diagnosis. Rarely the ossification may be extensive and simulate osteogenic sarcoma, as in the cases of Chambers, Paul (23), and one of Coley's (24). The simulation of such a form of myositis ossificans to sarcoma is not only apparent but real, since a definite percentage of these cases with extensive irregular ossification become malignant after an interval of years, recurring in spite of excision, to produce ultimate metastases and death (Fig. 44).

Fig. 35. Secondary chondromyxosarcoma arising at the site of an old exostosis in a white male, aged 25. The X-ray film shows the original base of the exostosis and the splintering of bone and spotty calcification typical of secondary chondromyxosarcoma.

Histogenetically, the source of the new bone is fibrous strands in the muscle, or tags of pre-cartilaginous embryonic connective tissue (blastema) displaced from the primitive periosteum; however, the reason for the heterologous ossification at these sites in the muscle is obscure. A hematoma seems to be an important antecedent to the ossification. Dean Lewis[6] emphasizes peri-

[6]Jour. Am. Med. Assn., May 5, 1926, LXXX, 1281.

osteal stripping by injury as a source of the new bone. This would account for some types which show direct ossification of the membranous type, but would not account for the myositis ossificans derived *via* cartilage (Fig. 45), which must involve strands of blastemal tissue. The dotted-veil appearance in the X-ray film, extending out into the muscle, is against the assumption that periosteum of any size has been displaced, since, as a limiting membrane of ossification, it tends to produce more circumscribed formation. In such cases, if displacement of periosteal tissue plays a rôle, it must be by the dispersion of cells or groups of cells from the cambium layer. The ossification in the abdominal wall following surgical incisions, reported by Lewis, is more obscure in nature. In the lower abdomen, the blastemal strands in the rectus abdominis in the region of its attachment to the pubis may be a source of the ossification, while in the upper abdomen, similar strands at the insertion of the ribs may account for the development.

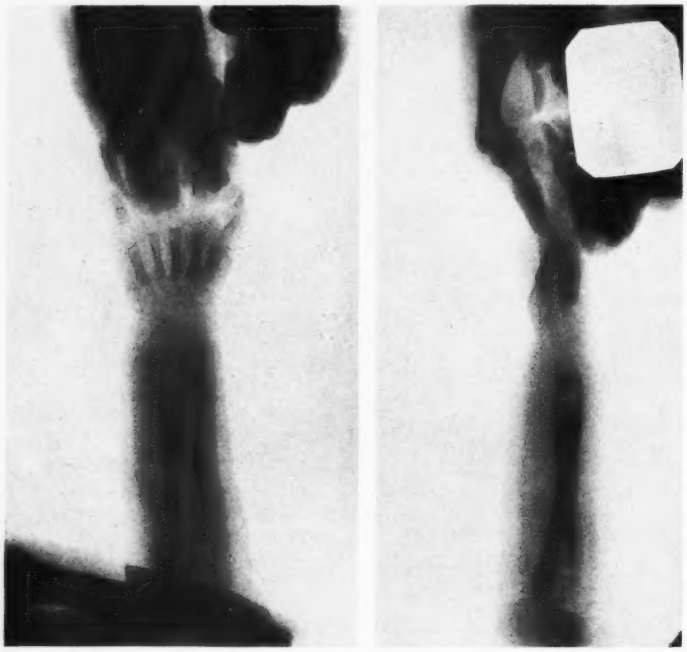


Fig. 36-*A*. Roentgenogram of an osteomyelitis in a child aged four. The area of bone destruction invades the epiphysis, and the periosteal reaction, with new bone, slopes upward beyond the mid-shaft region.

The prognosis in these cases is usually favorable. The symptoms attending the ossification may subside spontaneously, or, if persistent, will usually disappear with the surgical removal of the growth (23, 24).

3. Ossifying periostitis.—This is not a separate clinical entity but a phase of bone disease seen in such diseases as non-suppurative osteomyelitis of Garré, and syphilis. It is a benign condition which appears not infrequently about the tibia, humerus, or

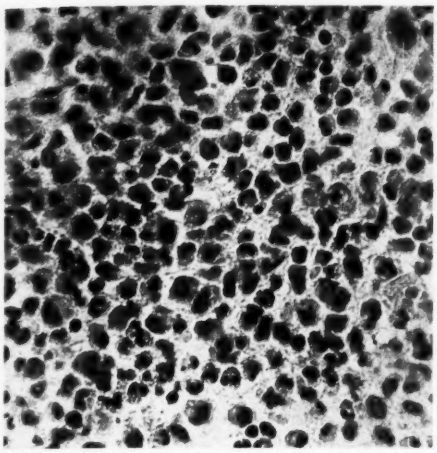


Fig. 36-*B*. Photomicrograph showing the leukocytic infiltration typical of osteomyelitis.

femur, as a single lesion in adults, generally between the ages of from fifteen to thirty-five. The usual basis for this dense ossification, producing a subperiosteal swelling, is either trauma or syphilis, and in no case should a Wassermann be omitted on a patient with such a lesion. The involved area is definitely circumscribed in most instances (Fig. 46) and affects usually one surface of the bone. When more diffuse and on the

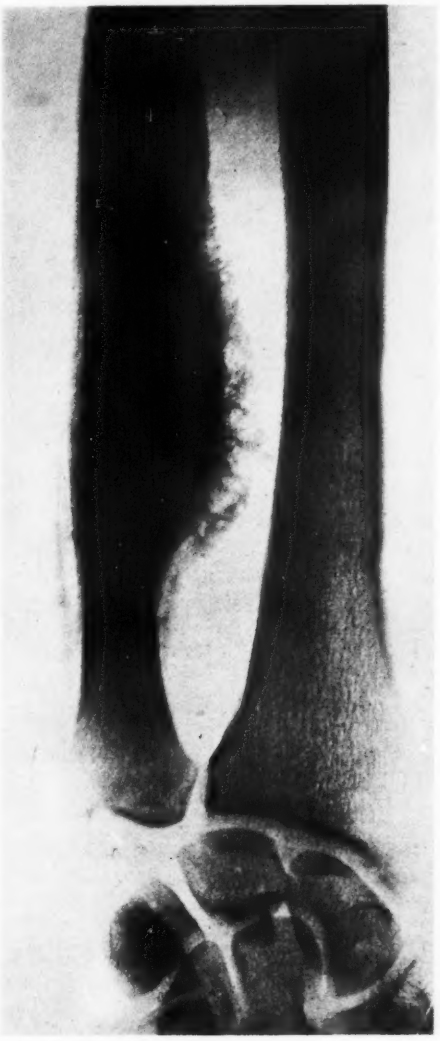


Fig. 38-*A*. This illustration, together with Figures 38-*B* and 38-*C*, depicts the bone-formative, the bone-destructive, and the microscopic phases of syphilis of the bone. There is sclerosis and new bone formation, with a periosteal involvement. This is an unusual picture in syphilis of an ossifying type which is more often restricted to the periosteum.

Fig. 37. Roentgenogram of a tuberculous humerus showing marked destruction in the epiphyseal end of the bone, with involvement of the joint.

basis of a low-grade chronic infection of the lymphatics in young adults, the reaction is referred to under the term "Garré's non-suppurative osteomyelitis."

Ossifying periostitis is a chronic disease, the usual duration of symptoms averaging

nearly eighteen months and in some cases extending back for from fourteen to sixty years. Pain, swelling, and some stiffness in the neighboring joints are the usual symptoms. In 10 per cent of the cases a definite abscess, carbuncle, or furuncle elsewhere in the body is associated with the development of the lesion. In over 10 per cent of the cases a positive Wassermann is present. One-fifth of the patients give a history of severe trauma.

Histologically, the areas of ossification are caused by raising of the periosteum, following the formation of granulation tissue or hemorrhage beneath this membrane. The granulation tissue may be due to infection, following abscesses elsewhere in the body, or previous systemic infection by typhoid, syphilis, or influenza. The hemorrhages are most often the result of trauma. The degree of ossification produced by such subperiosteal disturbance is dependent upon the extent and character of the injury and the age of the patient. In younger patients, ossification is more pronounced, and in rapidly subsiding infections and single traumas, new bone formation is likewise marked. In severe persistent infections, and in older patients, however, osteoporosis is always an accompanying feature.

Fig. 38-*B*. A bone-destructive process, with periosteal involvement more characteristic of advanced syphilis.

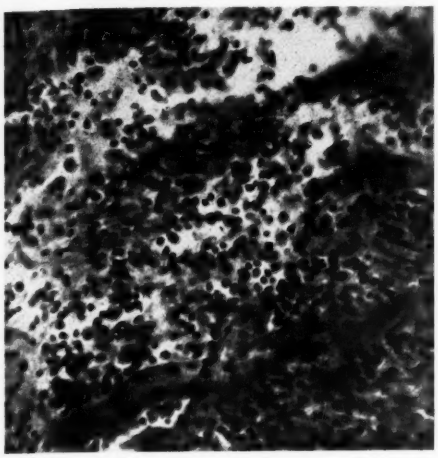


Fig. 38-*C*. Shows the inflammatory character of the lesion under the microscope, usual for syphilis, but also similar to that seen in tuberculous involvement of the bone.

in the adult.—In the differential diagnosis of ossifying periosteal lesions in the adult, it is important to bear in mind that there is an age overlap between the periosteal lesions more prevalent before the age of twenty, such as exostoses, periosteal osteogenic sarcoma, Ewing's sarcoma, and Garré's osteitis, described in Section I, and the fibrosarcoma, ossifying myositis, and ossifying periostitis just discussed. It may be difficult to distinguish between sclerosing osteogenic sarcoma, myositis ossificans, and ossifying periostitis in the roentgenogram. In differentiating between these three lesions, the location is an extremely helpful consideration. Osteoblastic osteogenic sarcoma arises from the subperiosteal region of the metaphysis, rapidly distorts the periosteal border

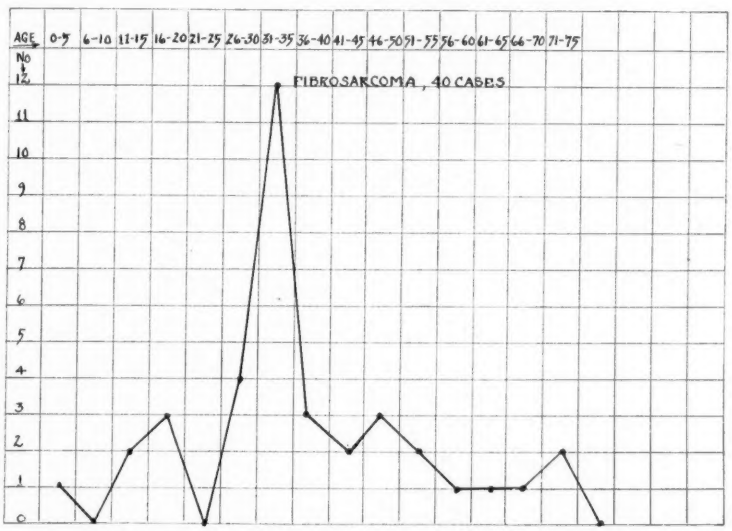


Fig. 39-*A*. Chart showing the age incidence of periosteal fibrosarcoma.

Incision of the periosteum, with scraping of the underlying bone, is usually a successful mode of treatment in protracted cases, other than of the syphilitic type.[7]

Summary of ossifying periosteal lesions

with irregular ossification, and produces medullary sclerosis by infiltration of the marrow cavity. Myositis ossificans arises above the periosteum within the muscle and although the superimposed shadow may obscure the underlying normal bone, if proper views are taken this supraperiosteal location

[7]For literature, see Section on Garré's Osteitis, Pt. I, Par. 4, Page 129.

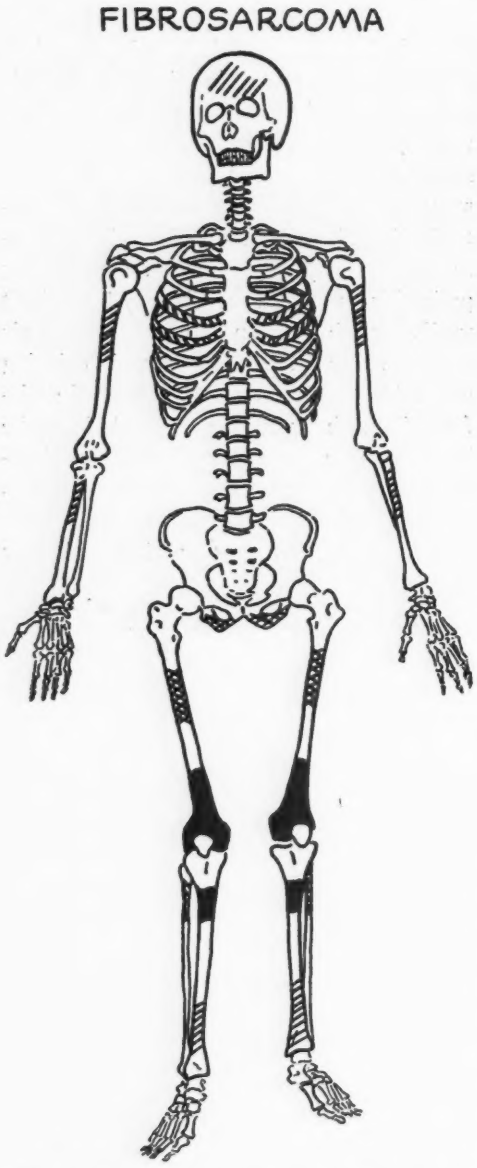


Fig. 39-*B*. Chart showing the skeletal distribution of periosteal fibrosarcoma. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occasional sites.

Fig. 40. Roentgenogram of a periosteal fibrosarcoma showing the large soft-part swelling and a slight amount of secondary new bone destruction.

of the ossification will be disclosed. Ossifying periostitis is a relatively slow mode of ossification laid down beneath the periosteum, usually in a region near the midshaft. The ossification does not invade the marrow cavity as in sclerosing sarcoma, nor is it as irregular and radiating in character, but instead, is more often parallel to the bone and more regular.

The resemblance of the advanced stage of Ewing's tumor to ossifying periostitis which is accompanied by osteoporosis may be a source of confusion to the roentgenologist. The onion-peel formation of the periosteum in Ewing's tumor is a helpful point in the diagnosis and the degree of ossification is generally more pronounced in the inflammatory lesions than in Ewing's sarcoma. The differentiation, however, may require biopsy. The location and the character of the soft-part shadow in fibrosarcoma should permit a more ready diagnosis.

Fig. 41-*A*. A cellular type of fibrosarcoma in which the cells are the small oat cell type and mitotic figures are numerous.

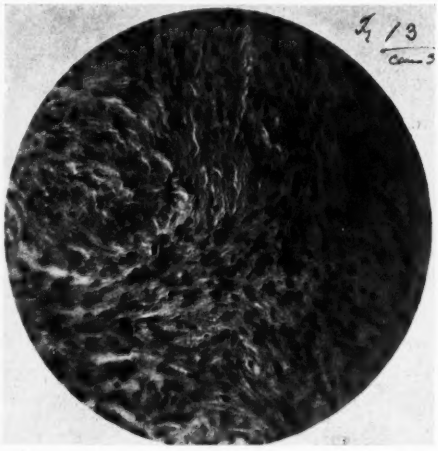


Fig. 41-*B*. Photomicrograph of a low-grade fibrosarcoma showing the fibromatous character of the tissue. Patients with this type of tumor do not succumb to metastasis. The lesion is best termed a fibroma.

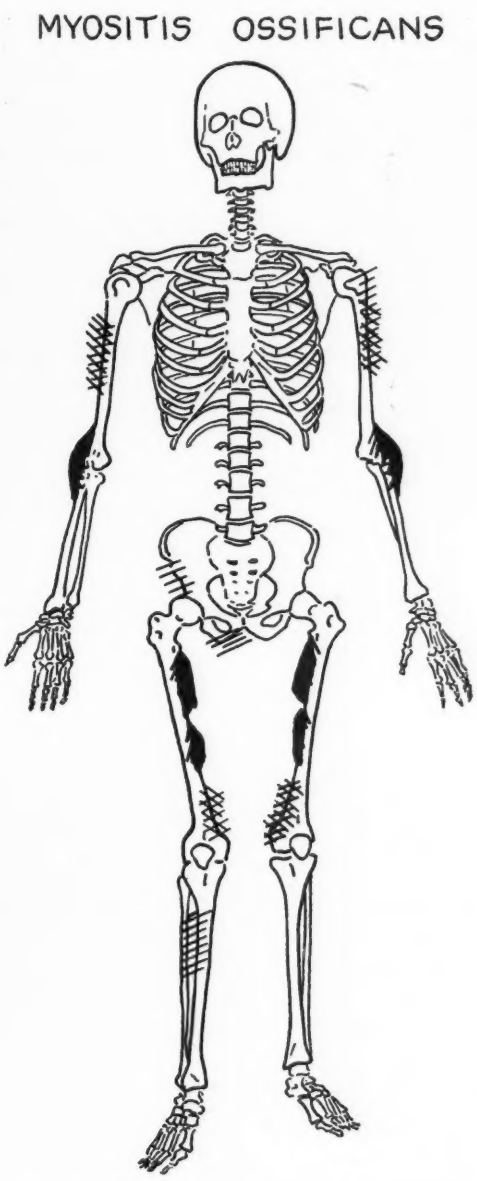


Fig. 42. Chart showing the incidence of myositis ossificans according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occasional sites.

V.—Solitary Osteolytic Tumors in Patients over Twenty

Among those tumors which produce in the X-ray film a single area of medullary bone destruction in adults over twenty, we must consider the benign giant-cell tumor of bone, the central chondroma or chondro-

myxoma, the single focus of metastatic carcinoma to bone, and the more infrequent latent bone cyst. Multiple myeloma in bone rarely presents itself initially as a single lesion early in the disease (Geschickter).

femur, and the lower radius are most frequently involved. The typical configuration of the tumor is a globular, trabeculated, rarefied area, asymmetrically located. Comparison of early and late lesions on the

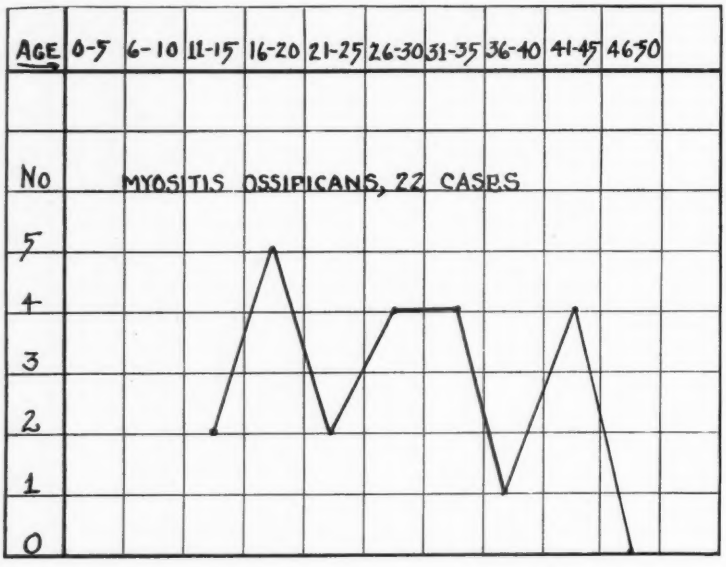


Fig. 43. Chart showing the age incidence of myositis ossificans.

and the possibility of this must be borne in mind.

1. Benign giant-cell tumor.—This benign lesion of bone occupies a relatively important position among the bone tumors, because of its frequency. The peak of the age incidence of this tumor occurs between twenty and thirty years (Figs. 47-*A* and 47-*B*), and females are slightly more often affected than males. Clinically, the lesion is progressive, with an average duration of symptoms of fourteen months, the usual sequence being trauma, pain, tumor, and fracture. The area of involvement is practically always single and shows in the roentgenogram as a circumscribed, bone-destructive lesion occurring in an epiphysis. The epiphyses of the upper tibia, the lower

X-ray films shows that the area of bone destruction begins in a subcortical location at one side of the epiphysis and works its way toward a more central location at the expense of cancellous bone (Fig. 48). The expanded bony shell of the tumor is extremely thin and in slightly less than 60 per cent of the cases is perforated. Pathologic fracture occurs in 14 per cent of the cases.

Histogenetically, the giant-cell tumor, with its cellular stroma pervaded by many large multinucleated giant cells containing from fifteen to two hundred nuclei (Fig. 49), is an exaggeration of the normal process of resorption of calcified cartilage by giant osteoclasts in intracartilaginous ossification which may occur in the epiphysis at any age throughout life. Giant-cell

tumors are related to bone cysts in that the histologic basis of each is usually the same, but whereas the bone cyst occurs in an earlier decade in a metaphyseal region, where ossification is in progress on the shaft side of the epiphyseal line during the growth period, the giant-cell tumor is practically always confined to the epiphysis, where the same type of ossification is not complete until late in life. The histogenesis and relation of these two tumors have been fully discussed in a previous contribution (Geschickter and Copeland, 9). From an X-ray standpoint it is important to bear in mind that these tumors arise only in bone derived from cartilage and are coincident with the normal resorption of calcified cartilage by giant-cell osteoclasts, a fact which gives these tumors their characteristic location and age distribution.

Giant-cell tumors are curable by prolonged X-ray therapy in proper doses, and by curettement. Although over 15 per cent of the curetted cases recur, the lesions are distinctly benign, and do not metastasize. The scattered metastatic giant-cell tumors recorded in the literature are few in number and have not yet been verified (Geschickter and Copeland, 12) (25, 26).

Fig. 44. Roentgenogram of a case of myositis ossificans showing the typical laminated structure of the bone deposits and the so-called "dotted veil" appearance.

2. Central chondroma or chondromyxoma.—The benign central chondromas and chondromyxomas are less frequent lesions than the giant-cell tumor and have quite a different distribution in the skeleton. These tumors occur most frequently between the ages of twenty and thirty and are more frequent after the age of thirty than before the age of twenty (Fig. 50). Males and females are affected with approximate equality. The tumors are usually single but may be multiple. They are always bone-destructive rather than bone-formative in nature and are central in location.

The clinical symptoms are never very severe, but are protracted, dating back frequently several years. The chondromas are not to be confused with the osteochondromas. These osteochondromas or exostoses, which have been discussed previously in this paper, are strictly periosteal lesions and have a different seat of origin than the chondromas, despite the fact that they may contain large portions of neoplastic cartilage indistinguishable under the microscope from the tissue characteristic of the central chondromas. The chondromas, on the other hand, have a characteristic distribution and a distinct mode of origin. This group of cartilaginous, bone-destructive tumors are practically restricted to the small bones of the hands and feet and to the articular regions of the spine and the sternocostal joints

(Fig. 51). In a series of seventy cases in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, there were only three central chondromas in the long bones —two in the femur and one in the shaft of the humerus. In order to understand the characteristics of this group of tumors and the peculiarity of their distribution, it is necessary to precede the X-ray studies by a discussion of their histogenesis.

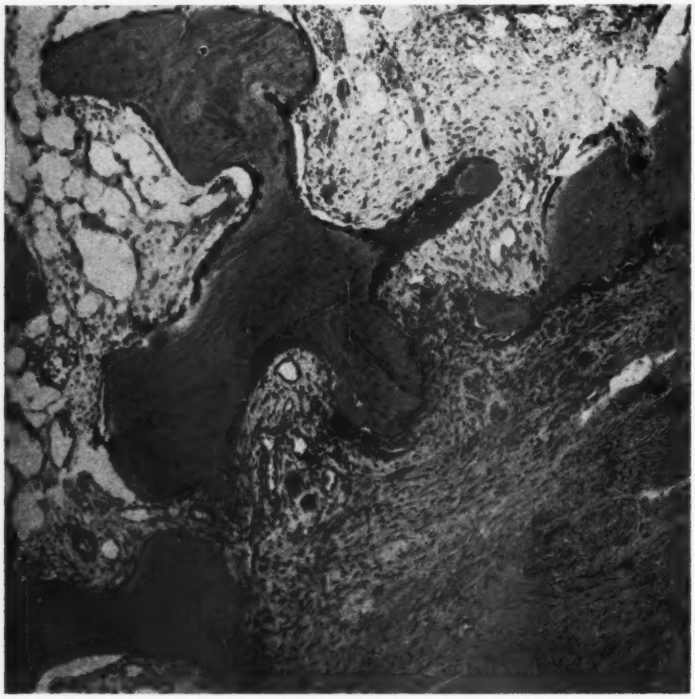


Fig. 45. Photomicrograph of new bone formation proceeding from fibrous tissue without the presence of cartilage, typical of the majority of cases of myositis ossificans.

Most of the chondromas and chondromyxomas represent histogenetically supernumerary joint cartilages. In the regions where they predominate—the hands and feet, the spine, ribs, and sternum—there are far more joints and articular surfaces than elsewhere in the body. Embryologically, these joints are laid down by strands of primitive pre-cartilaginous connective tissue which cut across the axis of the future bones at right-angles (Fig. 52). These pre-cartilaginous strands are the same type of blastema tissue which forms the osseous ends of tendons and gives rise to the abnormalities of exostoses and osteochondromas. This accounts for the similarity histologically between the chondromas and the exostoses. In forming the joints this pre-cartilaginous tissue undergoes mucoid regressive changes to form the synovial lined joint cavities. However, aberrant persistent strands which do not thus regress are responsible at a later date for the origin of cartilaginous islands in the bone which form

Fig. 46. A case of ossifying periosteitis showing dense, irregular new bone formation and a characteristic limitation to one side of the bone. This patient has had X-ray examination recently and the process has remained stationary for seven years.

the chondromas and chondromyxomas. It is for this reason that the chondromas are found most frequently in those parts of the body where there are the greatest number of joints.

In the X-ray films the typical chondroma is a small, translucent, rarefied area occurring centrally in the shaft of a phalanx. The cortical bone about the lesion is thinned and expanded, and pathologic fracture occurs in about 10 per cent of the cases (Figs. 53-*A* and 53-*B*). Unlike the osteochondromas, neither new bone formation nor calcification is characteristic of these lesions, although trabeculæ of dense fibrous tissue may be visible in the roentgenogram. Recurrences after incomplete operation and secondary malignant changes are occasionally reported in this group of tumors, but complete excision usually suffices to cure the condition, if young cartilage cells are not transplanted in the wound (*27*, 28).

3. Metastatic carcinoma to bone.—Metastatic carcinoma to bone is usually secondary to malignant tumors of the breast, prostate, thyroid, or to a hypernephroma. Growths in the bone secondary to carcinoma of the gastro-intestinal tract or the female genitalia are not rare, and cancers

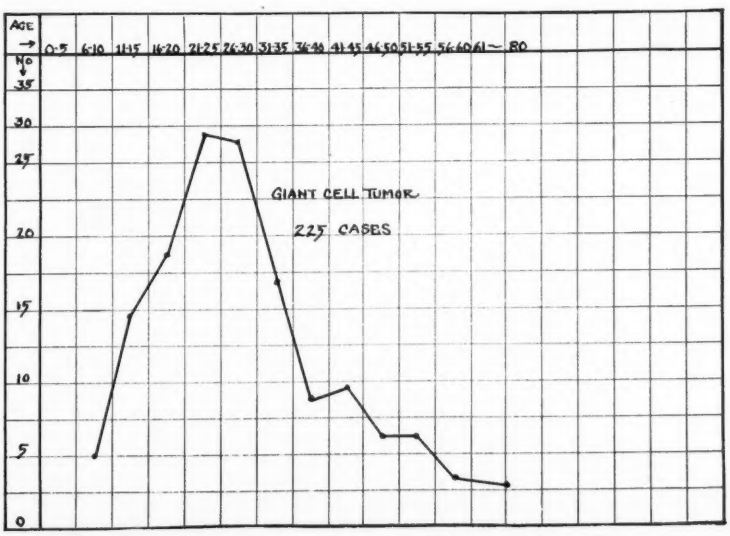


Fig. 47-*A*. Chart showing the age incidence of giant-cell tumor.

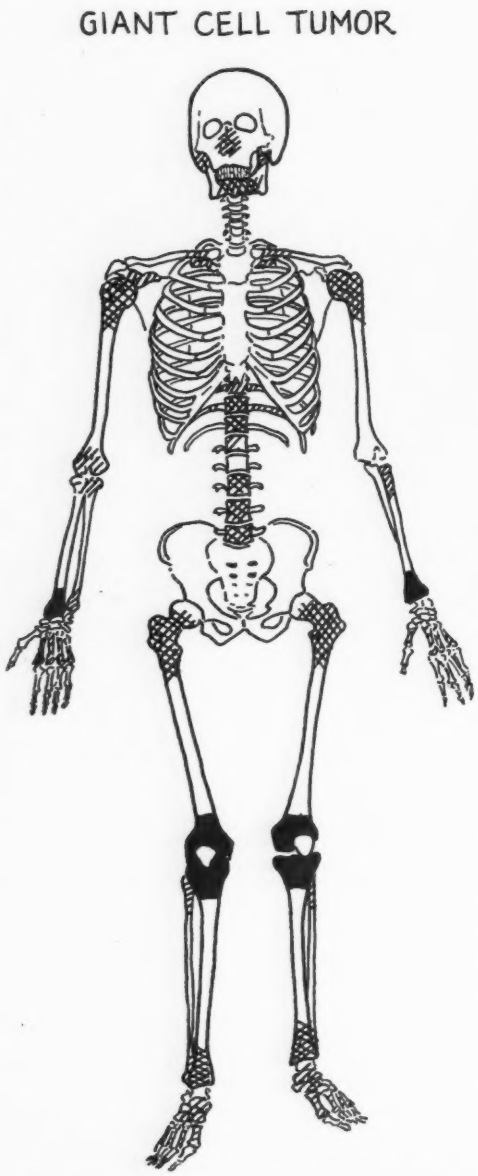


Fig. 47-*B*. Chart showing the incidence of giant-cell tumor according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occasional sites.

Fig. 48. Roentgenogram of a giant-cell tumor showing the epiphyseal location of the lesion, the asymmetrical expansion of the cortex, and the bone-destructive character of the growth.

of the skin or mucous membrane anywhere in the body may give rise to skeletal foci in the later stages of the disease. Such foci may be multiple or single or may arise by metastases either through a hematogenous or lymphatic route. A single focus of metastatic carcinoma in a long bone is generally the result of dissemination *via* the blood stream, and arises at the point of entrance of the nutrient vessel of the bone. The multiple foci which may arise from dissemination either *via* the lymphatics or blood stream will be discussed separately, below, under Multiple Tumors of the Bone.

Metastatic carcinoma of the bone is always a hopeless disease and occurs most frequently after the age of forty, with a maximum incidence in the decade of from fifty to sixty years. Females are affected more often than males. Pain of severe rheumatic character is the important clinical feature, but more helpful is the clinical discovery of the primary tumor elsewhere in the body. In the X-ray film the character-

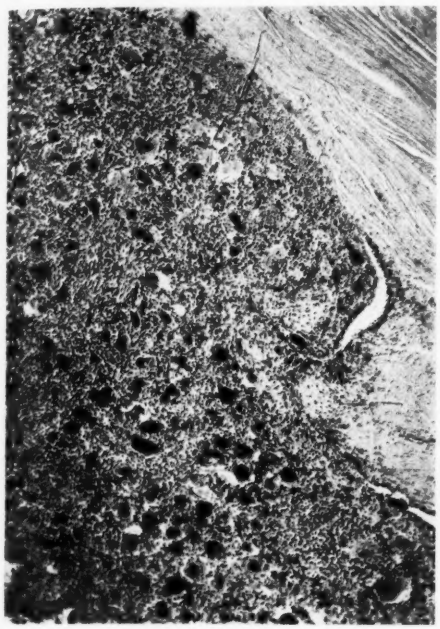


Fig. 49. Photomicrograph of a typical giant-cell tumor. There are over thirty giant cells to the low-power field and over fifteen nuclei to each giant cell. Note that in the stroma small round cells predominate.

istic picture is that of a central bone-destructive area occurring in the region of the entrance of the nutrient vessel of a long bone. The upper femur and the upper humerus are most frequently affected, or a single vertebra may be involved (Fig. 54). Metastatic carcinoma is rare in bones below the elbow or the knee. The configuration of the tumor in the roentgenogram is that of an etched-out area in the medulla of the bone. A symmetrical central location is most frequent, and about this the cortical bone is thinned or destroyed, usually without much expansion. Pathologic fracture occurs in about 35 per cent of the cases. The roentgenogram of the chest is often an important diagnostic aid, since it may reveal other metastatic nodules in the lung (29).

4. Latent bone cysts.—The latent bone cyst may occur at any age and is usually an accidental discovery in an adult who has had this quiescent lesion since childhood. Pathologically, it differs in no way from the juvenile bone cysts described previously in this paper, except that pathologic fracture is rarer and the bone shell about the cyst is thicker. The latent bone cyst of the adult is a more infrequent lesion than the bone cyst in youth, and constitutes less than 20 per cent

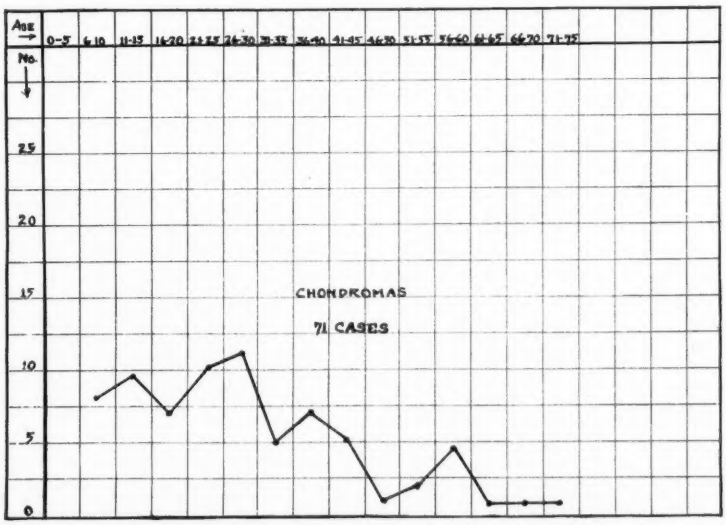


Fig. 50. Chart showing the age incidence of benign chondromas.

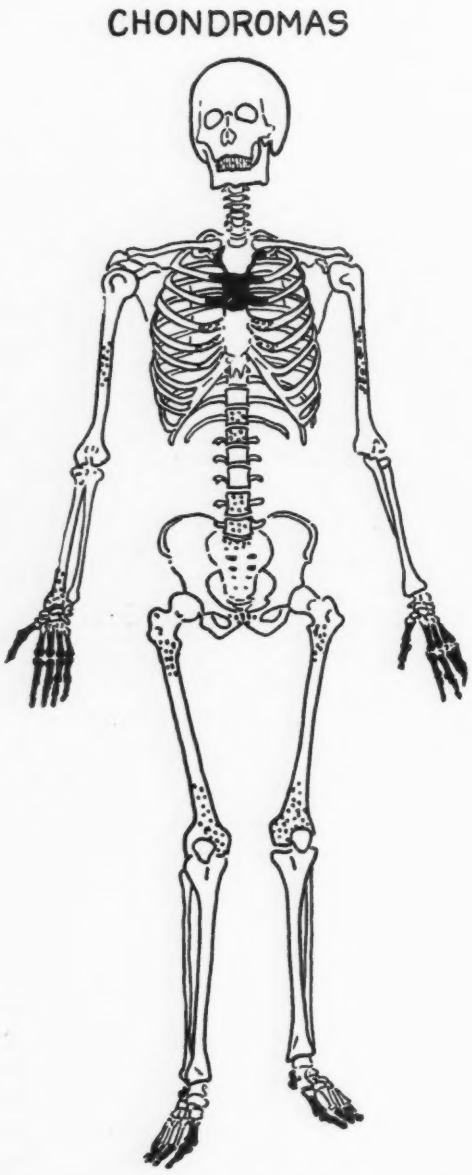


Fig. 51. Chart showing the incidence of benign chondromas according to skeletal location. The solid black areas indicate the most frequent sites and the dotted areas, the occasional sites.

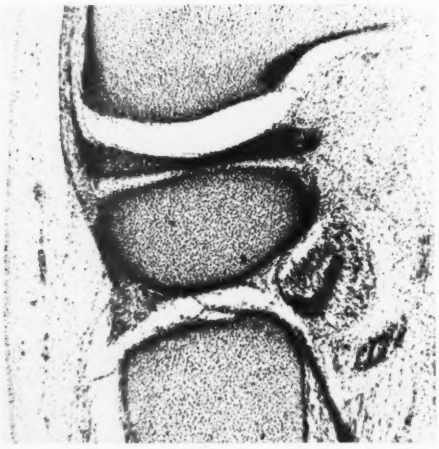


Fig. 52. Photomicrograph taken from a 14-centimeter human embryo showing early joint formation. The joint spaces are formed by separation in the strands of pre-cartilaginous connective tissue, which may be seen in the photograph transversing the joint cavity as a dense band. The tibia and femur are shown, formed by early fetal cartilage cells.

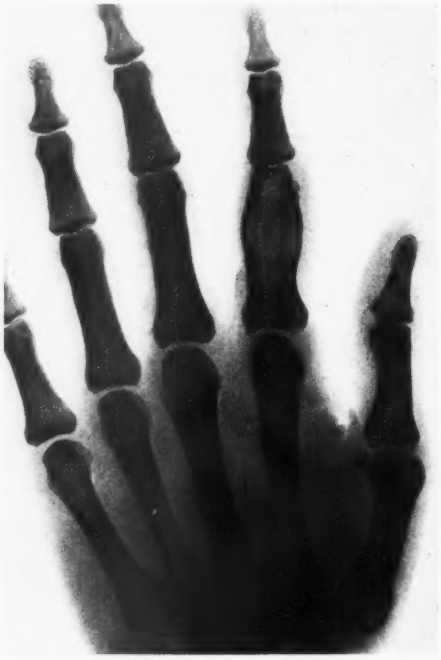


Fig. 53-*A*. Roentgenographic appearance of a benign chondroma, situated in the phalanx of the forefinger. The chondroma is a central bone-destructive lesion and is composed of adult cartilage separated by strands of connective tissue.

of all bone cysts. Its persistence is due to Nature's difficulty in collapsing a cavity with rigid walls and is not to be ascribed to con-

tinued activity in the pathologic process, which has long since subsided in most instances. In the X-ray film the rarefied area is central, smooth, and definitely circumscribed by a bone shell which is thick and

—Multiple myeloma has never been recorded as a single lesion, but the onset of the disease clinically may be characterized by the involvement of a single area in one bone. Such rare instances have occurred

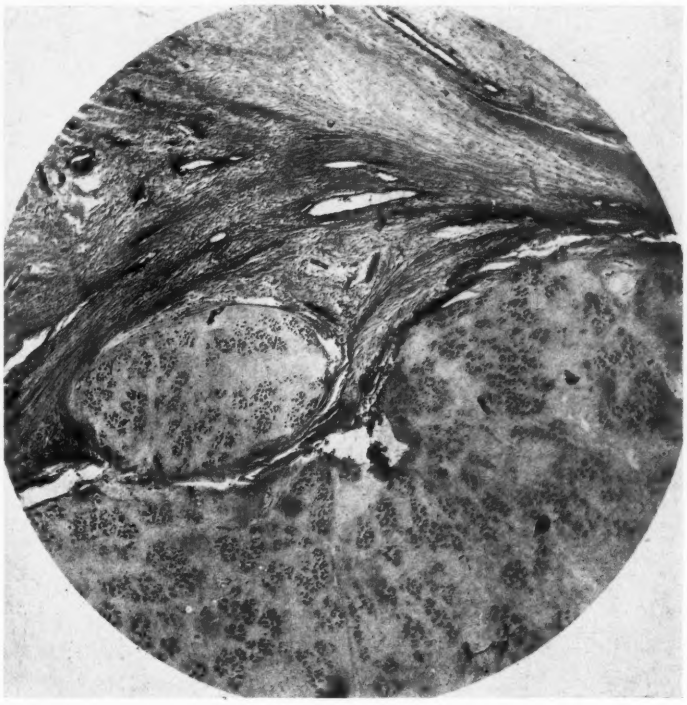


Fig. 53-*B*. Microscopic appearance of benign chondroma shown in Figure 53-*A*.

competent. Owing to the long duration of its existence, it tends to be further from the metaphyseal region where bone cysts arise, because of its transport toward the midshaft region, coincident with the growth of the bone (Fig. 55). The bones affected are the same as those of the juvenile bone cyst, *viz.*, tibia, humerus, and femur. Slight bending of the bone in the affected area is often brought about by the structural weakness caused by the cyst. Treatment is rarely, if ever, indicated (30).

5. *Multiple myeloma as a single lesion.* twice among the twenty cases now recorded in the Surgical Pathological Laboratory (31), but from an analysis of all cases reported in the literature,[8] such an onset must be considered even more infrequent than this series would seem to indicate. When it has occurred the age incidence and location of the tumor as well as the configuration of the lesion on the X-ray film does not differ from a solitary form of metastatic carcinoma described above (Fig. 56).

[8]C., F. Geschickter and M. M. Copeland: Arch. Surg. April, 1928, XVI, 807.

Fig. 54. Involvement of the humerus by solitary focus of metastatic hypernephroma. The X-ray film shows the central bone-destructive character of the lesion.

The diagnosis in such a case may be aided by the finding of Bence-Jones bodies in the urine, but in the last analysis must depend upon biopsy and microscopic examination. A fuller consideration of multiple myeloma is given subsequently under Multiple Tumors of the Bone.

PART B

NEOPLASTIC ENTITIES OF BONE OCCURRING AS MULTIPLE LESIONS

Multiple tumors of bone are rarer than single lesions and occur about one-tenth as frequently as tumors of the solitary form. When multiple skeletal involvement does occur, the patient is more apt to be an adult than a child. This is because the largest group of multiple bone tumors is

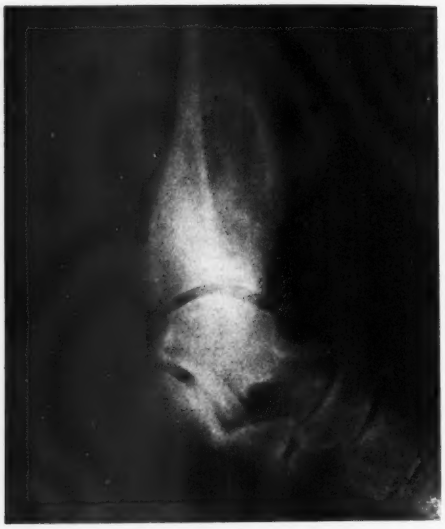


Fig. 55. Roentgenogram showing a latent bone cyst in the lower tibia in a man of 50. The tumor is of twenty-five years' duration and is well circumscribed by a thick shell of cortical bone. The lesion was completely healed and ossified three and one-half years after curetting.

Fig. 56. Roentgenogram of the femur in multiple myeloma, appearing clinically as a single lesion, in a white male, aged 45. There were no symptoms except pain and limping of two months' duration. The X-ray film shows a central area of bone destruction at the site of the nutrient vessel, with an intact shell of cortical bone. There is no periosteal reaction.

made up of metastatic carcinoma, multiple myeloma, and Paget's osteitis deformans, all three of which are practically restricted to patients over thirty-five and usually over fifty. Among youthful patients, multiple exostoses, disseminated osteomyelitis, multiple bone cysts, and fragile bones occur in the order of frequency given. These various types of multiple lesions of bone are discussed under the following chapter headings:

I. Multiple Osteoplastic Lesions Prevalent in Patients under Twenty; II. Multiple Osteolytic Lesions Prevalent in Patients under Twenty; III. Multiple Osteoplastic Lesions Prevalent in Adults; IV. Multiple Osteolytic Lesions Prevalent in Adults.

I.—Multiple Osteoplastic Lesions Prevalent in Patients under Twenty

Multiple bone-forming lesions in children are usually multiple cartilaginous exostoses.

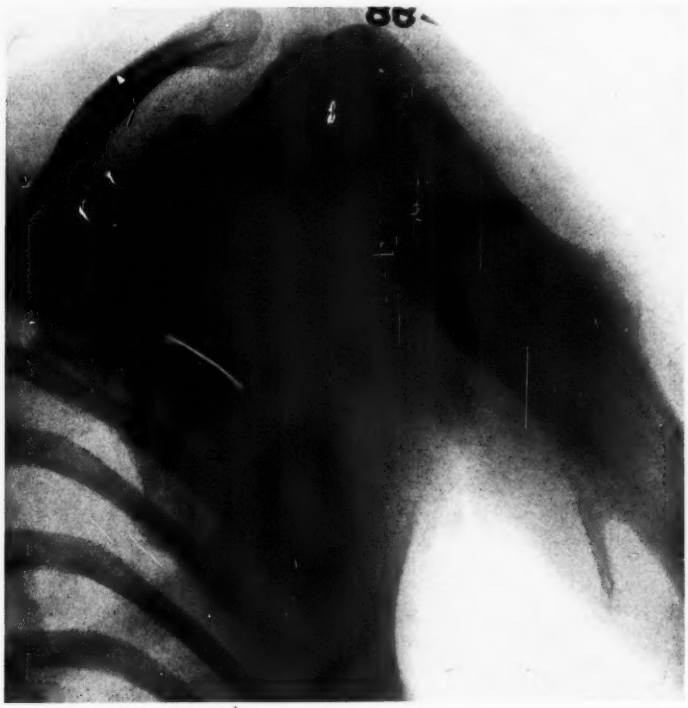


Fig. 57. Roentgenogram of a child with hereditary deforming chondrodysplasia or multiple exostoses. Besides the multiple exostoses present, there is widening of the metaphyseal ends of the bones, curvature in the bones of forearms and legs, and deformities in the cortical zone at many points in the shaft.

These lesions resemble closely the single exostoses already discussed in Part A, Section I. Rarely, the osteoblastic form of osteogenic sarcoma may metastasize to other bones and thus give rise to multiple skeletal tumors of the most malignant sort; Ewing's sarcoma more frequently metastasizes to other bones, and may also be the cause of multiple skeletal involvement in patients under twenty: in either form of metastatic sarcoma, the diagnosis can be made on the basis of the original bone lesion, the char-

Fig. 58. Roentgenogram illustrating the deformity and fusion of bones of the legs in a case of hereditary deforming chondrodysplasia.

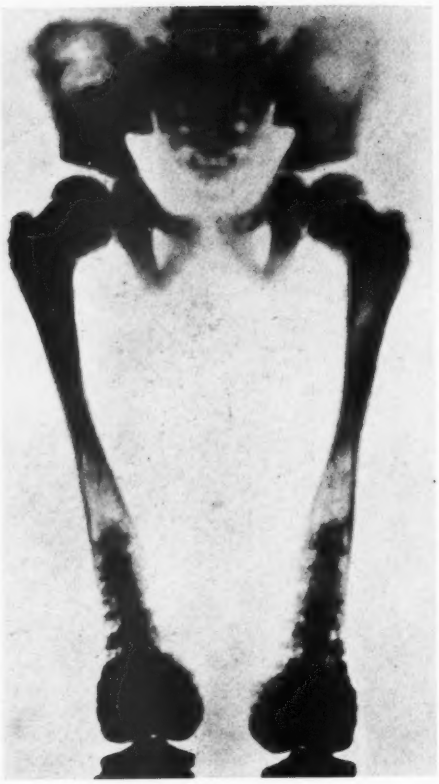


Fig. 59-*A*. Roentgenograms illustrating osteosclerosis, or marble bones. Typical sclerosis of the metaphyseal and epiphyseal regions, affecting a child who had multiple fractures. Courtesy of Dr. George G. Davis (35).

acteristics of which have already been described. A very unusual type of bone dystrophy may be present in juveniles and produce increased density in many bones. This is the so-called "marble bones," a variety of bone fragility known also as Albers-Schönberg's disease.

1. Multiple exostoses (Chondrodysplasia).—Multiple exostoses in children constitute a congenital, hereditary disease, which occurs about one-tenth as frequently as the single form. The hereditary factor is apparently direct or indirect, as in color blindness (transmitted by females to males). The disease is a congenital disturbance in the primitive perichondrium and hence affects markedly the growth of the bones. Not only do the tags of the perichondrium in the tendon ends proliferate to form the cartilaginous caps covering the bony outgrowths described under single exostoses, but disturbances and deficiencies in the periosteum in the metaphyseal regions lead to widening of the metaphysis and inhibiting of the bone growth. For this reason the X-ray films taken of this condition disclose numerous typical osteochondromas affecting the metaphyseal regions of the bones (Fig. 57), and, in addition, widening of the metaphysis and variation in the length of the bones. The bones most frequently and severely affected are those of the forearm and leg. The membranous bones of the skull are not involved, but any of the other bones of the head or body may be distorted

Fig. 59-*B*. A rarer type of this disease affecting the small bones of the wrist in an otherwise normal adult.

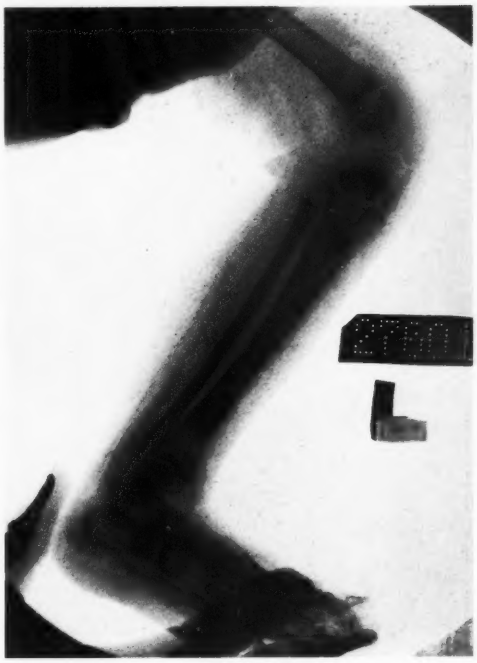


Fig. 59-*C*. Roentgenogram of a case of scurvy showing the dense line just behind the epiphysis and the periosteal involvement, typical of this disease.

by these growths. Most of the deformities occur in the cortex of the bone, which may be widened at irregular intervals along the entire shaft, giving a wavy outline, accentuated at points into plateaus of decreased density. Where two neighboring bones are affected, as in the radius and ulna, fusion may occur between these expanded and rarefied areas of the cortex (Fig. 58). Bending of the bones is frequent and occasionally central chondromas may be formed in the metaphysis by ingrowth of the cartilaginous areas which resemble bone cysts in the roentgenogram.

Such bone distortion, in association with multiple exostoses, makes the roentgenologic

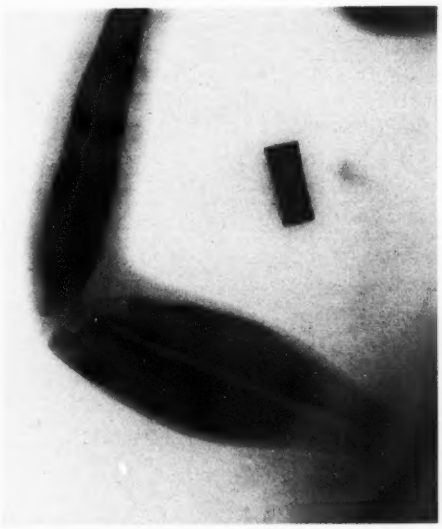
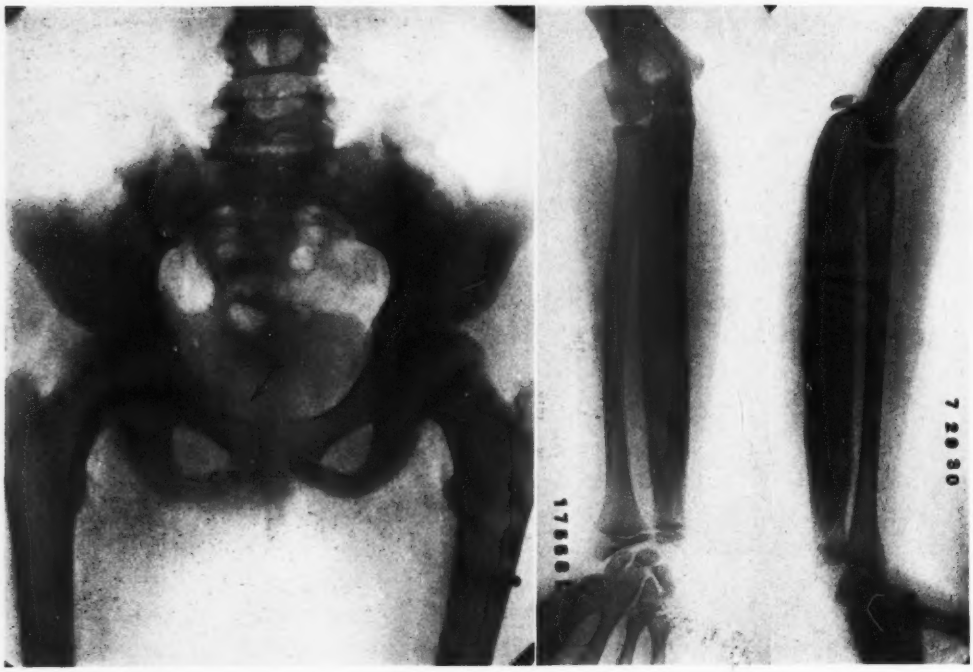


Fig. 60. Roentgenogram showing a bone dystrophy in a white male, aged seven, in which there is new bone formation restricted to the diaphyseal regions. The new bone formation also involves the skull, occluding various foramina. This is an unclassified form of juvenile bone dystrophy.



Figs. 61-*A* and 61-*B*. Roentgenograms of a case of osteomyelitis in a young child, which originated in the bones of the pelvis and metastasized to the bones in the forearm. Note the numerous small punched-out areas in the metastatic foci.

diagnosis extremely easy. A familial history of the early onset of the disease in a youthful patient, with stunted growth, is reaffirming evidence.

The prognosis for life in these cases is good, but there is no adequate form of treatment except operation for correction of deformities after the growth period has ceased. In two cases we have observed secondary malignant change in these cartilaginous growths, resulting in death from chondromyxosarcoma (*32*, 33).

2. Marble bones.—This appears to be the rarest form and the most recently recognized of the group of cases in the bone fragility class. It is essentially a disease of children, although Reiche (34) described a case in a man aged 37. The usual age is between twelve and twenty years. Clinically, these patients come under observation because of pathologic fracture, or abnormalities in the cranium. The sella turcica may be small, and narrowing of the cranial foramina, with consequent optic atrophy, may occur. The teeth are usually decayed and poorly formed. Calcification about the ligaments has been described, with occasional premature calcification of the vessels. The roentgenogram of the bones is characteristic. The metaphyses and epiphyses of the long bones are sclerosed by increased calcification (Figs. 59-*A* and 59-*B*), while the small bones of the hands and feet and the vertebræ show a definitely increased compactness originating in similar zones. Pathologic fractures are frequent. Characteristic transverse rings of calcification at the ends of the long bones have been referred to in the literature as a diagnostic feature. The children affected are gen-

erally poorly nourished and are apt to die of intercurrent infections (35).

3. *Infantile scurvy.*—Infantile scurvy is a deficiency disease due to a lack of Vitamin water-soluble C. It is identical in its essentials with the scurvy found in adults, but the infantile form has a more acute onset and the character of the bony changes is influenced by the undeveloped state of the affected bones. This type of scurvy begins most frequently between the sixth and tenth months of life and reaches an acute stage in two or three months. In children thus affected, motion is extremely painful and there is a pseudoparalysis because of the immobile state in which the limbs are held. Hemorrhages in the neighborhood of the bone are an outstanding characteristic of the disease. The most severe of these occur beneath the periosteum and about the teeth, but they also occur in the muscle substance near the bone, or subcutaneously, and hematuria is often present. The swelling about the epiphyseal line and about the joints, the extreme pain on pressure in these regions, subcutaneous hemorrhages, and the purple bleeding gums form a typical clinical picture.

In the X-ray film (Fig. 59-*C*) there is, behind the epiphyseal line, a marked increase in the density of calcification, described as "the white line." There is also a widening of the distance between the shaft and the epiphysis and the small epiphysis may have a characteristic ring about its edge. Subperiosteal hemorrhages followed by a slight amount of new bone formation are seen in advanced cases but may be slight and easily overlooked in an early stage. If the disease has not progressed too far, it yields promptly to a diet of fresh whole milk and orange juice.

Summary of multiple osteoplastic lesions in children.—Multiple osteoplastic lesions are not difficult to diagnose when occurring in the young. The most frequent multiple tumor met with is the congenital cartilaginous exostosis, which can be readily diagnosed by the typical outgrowths in the cortical zone, the variation in length of the bones of the skeleton, and the metaphyseal widening. The hereditary history which can usually be obtained clinches the diagnosis. Marble bone is a rare condition and should be recognized by the series of calcified rings, sclerosing the epiphyseal and metaphyseal regions. Ewing's sarcoma, with skeletal metastases, can be diagnosed from the character of the lesion in the bone first affected. Rarely in a child under ten there will be forms of bone dystrophy accompanied by diffuse ossifying periostitis affecting the shafts but not the epiphyses of all of the long bones. Similar ossification in the skull will lead to optic atrophy and deafness by encroachment on the foramina of the cranial nerves. The X-ray films of such a case are shown in Figure

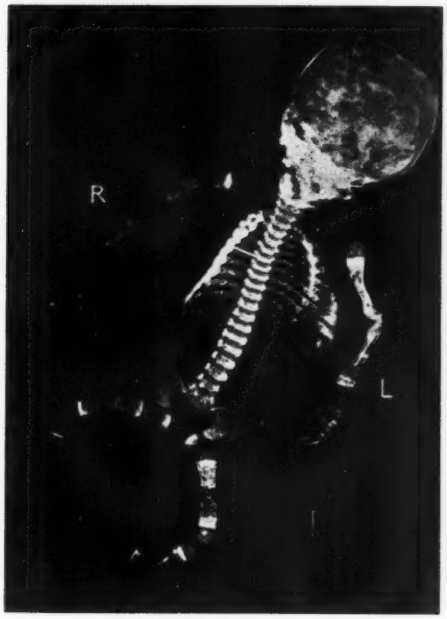


Fig. 62-*A*. Roentgenogram of the complete skeleton of a still-born child with osteogenesis imperfecta. *From Knaggs' "Diseases of Bone," William Wood & Company, N. Y., 1926, page 376.*

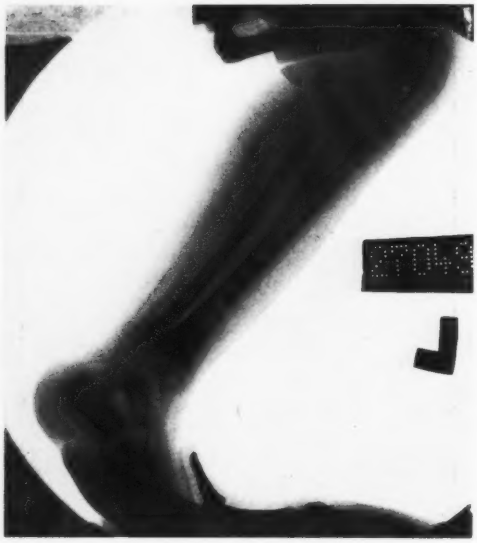


Fig. 62-*B*. Roentgenogram of a case of rickets showing the saucer-like changes at the epiphyseal line.

60. No adequate diagnosis can be made of such conditions, nor is the ultimate outcome predictable.

II.—Multiple Osteolytic Lesions Prevalent in Patients under Twenty

Multiple osteolytic lesions in children are usually benign. Metastatic osteomyelitis, with multiple bone involvement, is perhaps the most frequent form of this group of lesions. Bone cysts, usually containing giant-cell areas, may occur in several bones of the same patient, but there is always some complicating skeletal disease, such as congenital syphilis or fragilitas ossium. The latter type of disease, known often as osteopsathyrosis, occurs in several well-recognized forms.

1. Metastatic osteomyelitis.—While acute osteomyelitis in a child usually involves a single bone, several bones in the same patient are affected in about 15 per cent of the cases. When multiplicity occurs, an interval of time varying from days to weeks in duration may elapse between the primary infection in the first bone and the involvement of other areas of the skeleton. The development of these secondary foci is usually marked by chills and fever and the bones last involved are not so severely affected. The stage of necrosis may not be reached and swelling only, with or without pus formation, may occur. If many bones are successively involved, internal abscesses and fatal septicemia are apt to follow. Trendel (36) found that in 1,058 cases of acute osteomyelitis, 166 had multiple bone involvement, the usual case having two or three bones affected. In only 13 cases were from four to ten bones involved. In one-third of the multiple cases, the short or flat bones were involved along with the long bones.

In the X-ray film the usual source of confusion is the involvement of the flat bones, which may show one or more eaten-out areas which in themselves are not diagnostic and which can be interpreted only when studied together with the other bone involvement and the clinical history. These punched-out, necrotic areas may occur in the ends of the long bones of children (Figs. 61-*A* and 61-*B*), but are more often seen in the ilium or scapula.

2. Bone fragility.—Idiopathic bone fragility has been described in numerous forms and under a group of conflicting terms. Among the German authors many of these lesions have been grouped together, under the term of idiopathic osteopsathyrosis, comprising several well-recognized varieties, including:

(*a*) Osteogenesis imperfecta, a non-hereditary disease, with multiple fractures; present at birth; the infants usually die.

(*b*) Fragilitas ossium, an hereditary form, accompanied by such features as brittle bones, blue scleræ, deafness, and loose joints, also a proneness to pathologic fracture.

(*c*) Marble bones, or Albers-Schönberg disease, already discussed, which is characterized by dense lime rings in the metaphyseal and epiphyseal regions of the long bones, pathologic fracture, and excessive calcification in periarticular structures.

Information at the present time is not sufficient to permit of a rigid separation of these various forms of bone fragility, although in well-defined cases it is often easy to classify the condition under one of the three heads given above. More often the exact nature of the osseous change is obscure and does not lend itself to classification. In the brief descriptions given below we have chosen two forms in which rarefaction of the bones occurs.

Osteogenesis imperfecta: In outspoken cases of osteogenesis imperfecta, the children are either still-born or survive only a short time. The skeleton is riddled by truly spontaneous fractures of the extremities and ribs, with consequent deformity and shortening. The ossification in the skull is usually very incomplete. Typical cases have been cited by Knaggs (*37*) in "Diseases of Bone" (Fig. 62-*A*). In cases that survive in-

Fig. 63-*A*. Roentgenogram illustrating fracture deformities in a case of fragilitas ossium showing very well the bloated and expanded ends of the bone, which are unusually broad and foamy in appearance. The fracture in the splinted leg has occurred through a cystic area.

fancy and reach childhood (varying in age between eight and twelve years), marked bending of the bones may occur, with development of cystic areas in the metaphyseal regions, roentgenologically not unlike present, which helps to distinguish this group from "marble bones," in which gradual occlusion of the foramina in the skull occurs.

In the X-ray films the bones have a

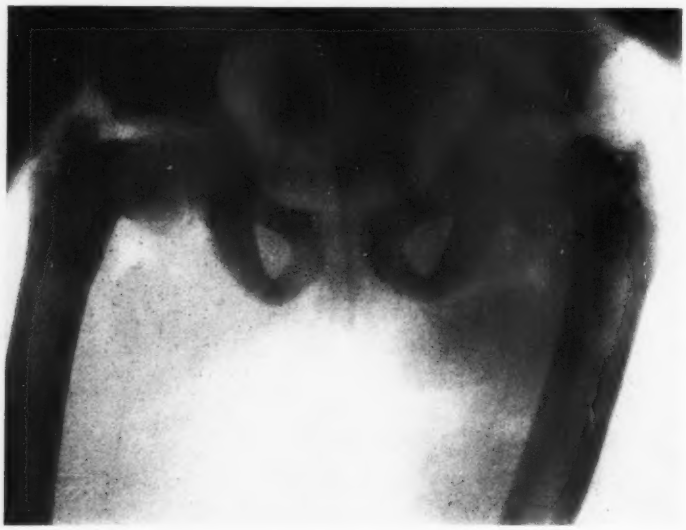


Fig. 63-*B*. Shows a pronounced coxa vara, with multiple fractures about the necks of both femurs. Same case as shown in Figure 63-*A*.

the solitary or multiple bone cysts described elsewhere. The numerous fractures may heal but the deformity continues and nonunion at one or more sites is the rule.

Fragilitas ossium: Fragilitas ossium, which is more frequent between the ages of eight and sixteen, at the time of clinical recognition is probably best represented by the well defined group referred to as "brittle bones" and "blue scleræ." This disease is practically always of the hereditary type, being transmitted from parents to children in a direct fashion. The outstanding clinical characteristics are the fragility of the bones, with accompanying fractures and deformities, the blue color of the scleræ, and deafness, which is generally of the otosclerotic type. Optic atrophy is not usually characteristically thin cortex, except where repeated fractures have stimulated increased ossification. The shafts of the long bones are more slender than normal, whereas the ends, including the metaphyses and epiphyses, are unusually broad and foamy in appearance. Slight bowing is present in most of the long bones, which may be markedly increased by fractures and malunion. Key (38) reports 70 per cent of fractures in the cases reviewed by him (Figs. 63-*A* and 63-*B*).

Rickets.—Rickets is a nutritional disturbance affecting the calcium and phosphorus balance and leading to marked bony changes, found in children suffering from a deficiency in Vitamin fat-soluble A. While there are a few scattered cases of late rickets in pa-

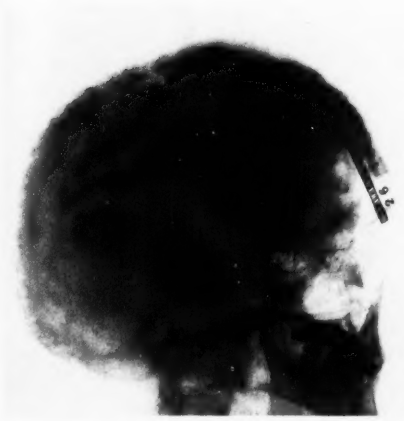


Fig. 64-*A*. A case of Paget's osteitis deformans involving the skull, pelvis, femora, and tibiæ. Note the widening and roughening of the tables of the skull, spoken of as of "nigger wool" appearance.

Fig. 64-*B*. Shows a characteristic anterior bowing of the tibia. Same case as shown in Figure 64-*A*.

tients between the ages of twelve and twenty, the usual age of onset varies between one and three years of age. The leading deformities in the skeleton are bending of the long bones, beading of the ribs at the costo-chondral junction, cranial tabes (undeveloped patches in the skull bones), with skull deformity, stunting of growth, and pathologic fracture. If the disease begins before the age when the normal child learns to walk, the patient is delayed in learning this function. There is usually under-nutrition, irritability, lowered resistance, and a marked susceptibility to pneumonia (Fig. 62-*B*).

In the X-ray film the most diagnostic feature is a "saucer-shaped" epiphyseal line, which is widened and extremely irregular, with bone absorption or decalcification occurring on either side of it. Atrophy in the ends of the bone may be marked, and if the child has walked, bowing of the tibia may be extreme. The sternal ends of the ribs show widening or fracture, and similar deformities. The spine shows a single long posterior curve from the cervical region downward, with a compensating anterior curve in the neck. The pelvis is deformed either by flattening in the antero-posterior diameter, or by funnelling due to the pressure of the femurs upward. The skull has a squared appearance, flat on top and long in its parietal direction.

The treatment is specific. It should aim at introducing the factor of fat-soluble Vitamin A (sunlight and cod liver oil) and securing the proper grade of milk for the child.

Summary of multiple osteolytic lesions in children.—The differential diagnosis in

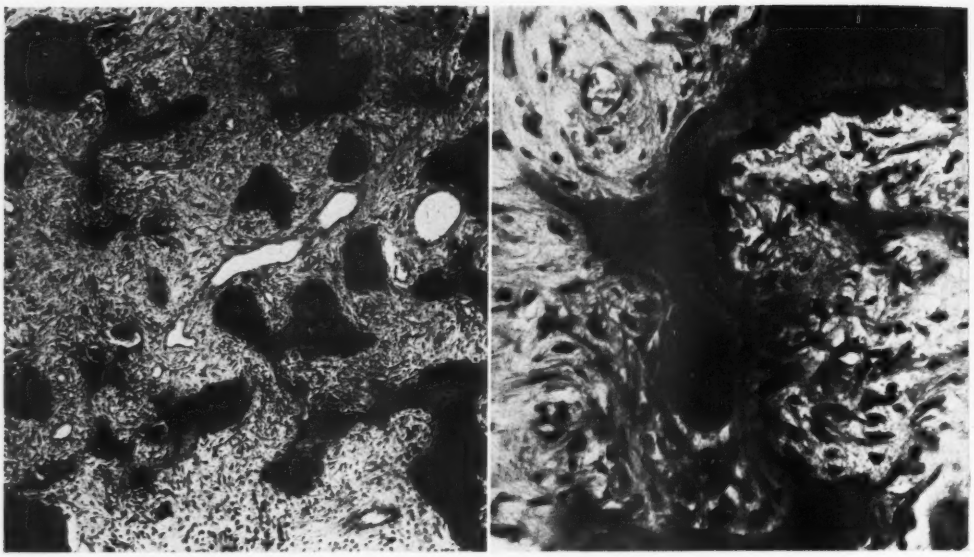


Fig. 65. Photomicrographs showing the pathologic changes in Paget's osteitis. The spicules of new bone can be seen undergoing secondary resorption through the activity of giant-cell osteoclasts. Both low and high magnifications are shown.

multiple osteolytic lesions in children is not difficult. Multiple osteomyelitis usually shows at least one bone affected in a characteristic manner, with irregular bone destruction and new bone formation. The lesions, although multiple, are focal and not diffuse. In bone fragility, there is a diffuse involvement, the shafts of the bones being abnormally slender and the ends widened, and often cystic. Pathologic fracture is the rule in bone fragility, but practically never occurs (under 2 per cent) in osteomyelitis. The difficulty in the bone fragility group of cases is not in the recognition of the presence of the dystrophy, but in the classification of this group of cases on the basis of inadequate present-day knowledge. In the very young, cases with multiple fractures are usually due to osteogenesis imperfecta. In a child just before puberty, with a characteristic familial history and blue scleræ, the case is safely classed as one of brittle bones. Other less well-recognized cases are perhaps best left unclassified and described in detail as independent forms of bone dystrophy.

III.—Multiple Osteoplastic Lesions in the Adult

The usual bone-forming tumor showing multiple skeletal involvement in the adult is Paget's osteitis deformans. This disease, which in all probability is not of neoplastic nature, may be closely simulated by multiple metastatic carcinoma. While surgical intervention is not necessary in either case, it is important to make the distinction in the diagnosis, because of the difference in prognosis. Paget's disease in the skeleton runs a benign and protracted course and unless sarcoma of the bone arises as a secondary change (approximately 5 per cent), the life of the patient is not materially affected. On the other hand, metastatic carcinoma is always a hopeless disease.

Osteitis deformans.—Paget's disease of

the skeleton affects primarily male adults, usually past the age of forty-five. The bone involvement is most often multiple, affecting the tibiæ, skull, and the pelvis, in the order of frequency given. The femurs are also prone to involvement. When the disease occurs as a single lesion, the tibia is most usually affected. When it is generalized, the spine is sooner or later involved. The clinical appearance of the patient in an advanced case is characteristic. The skull is enlarged and squared across the front; the tibiæ are bowed forward, and the femora bent laterally; the pelvis is widened and a gradual lordosis affects the spine; varicose veins are present in the lower extremities, and tortuous sclerotic arteries are frequent.

In the X-ray film the characteristic appearance of the skull is described as "nigger wool." The bones of the calvarium are thickened from two to five times their normal extent and are made up of areas of varying density, with a very fuzzy inner and outer table. The tibiæ are bowed, and the cortex added to by new bone formation of decreased density in the subperiosteal zone. Cyst formation may occur beneath the cortex and most commonly is located in these bones of the leg (Figs. 64-*A* and 64-*B*). The pelvis and femora, when involved, present similar pictures to the tibiæ. The bones are widened by new bone of decreased density, but cysts are less frequent in these regions.

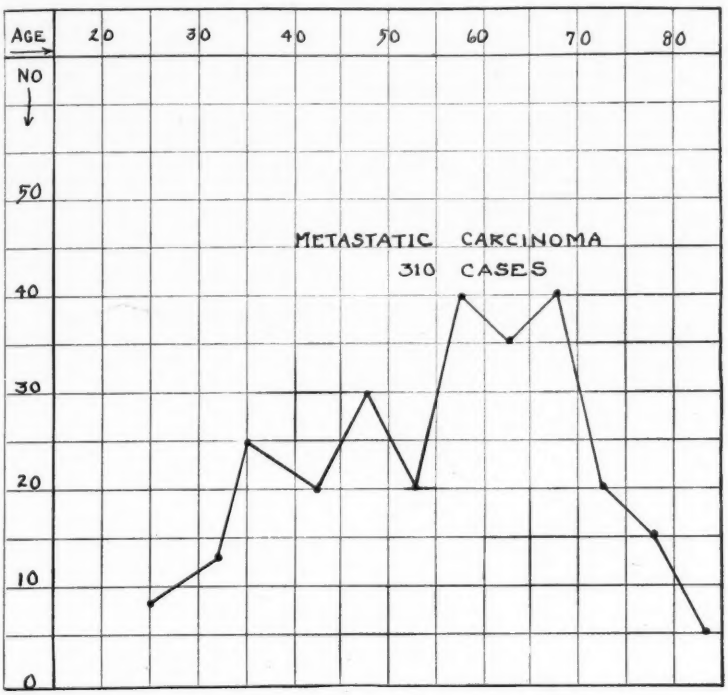


Fig. 66-*A*. Chart showing age incidence of metastatic carcinoma of bone.

Histologically, the basis of the disease is bone absorption replaced by ossification of a low order. Under the microscope giant-cell osteoclasts may be seen destroying old spicules of laminated bone, while at the

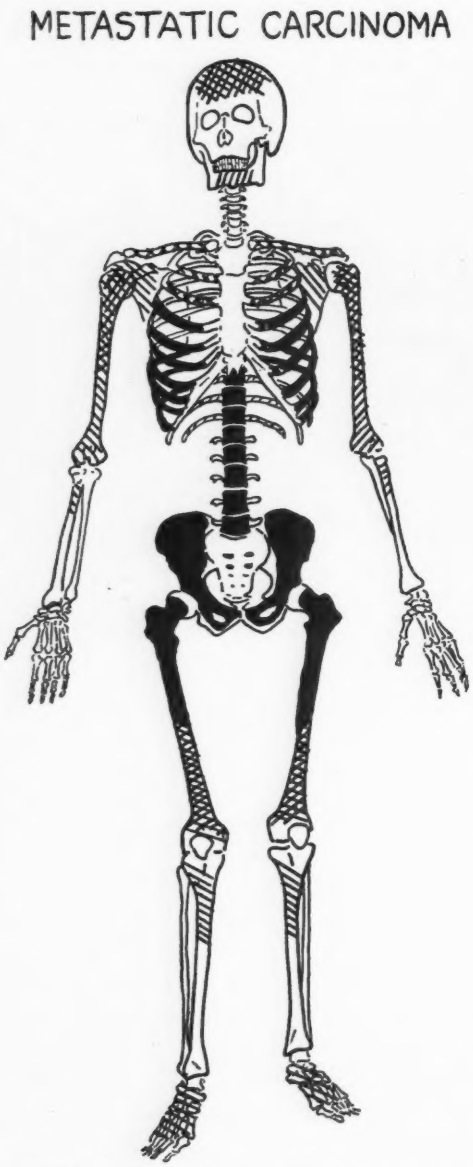


Fig. 66-*B*. Chart showing the skeletal distribution of metastatic carcinoma of bone. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occasional sites.

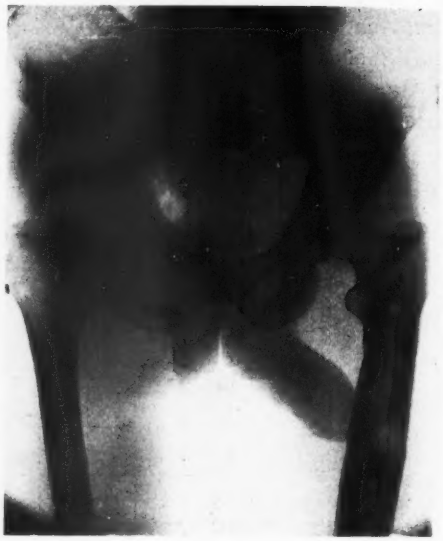


Fig. 67-*A*. Roentgenogram of multiple areas of bone destruction due to metastatic carcinoma. Note that the areas of bone destruction are discrete but overlapping like the links of a chain.

same time there is an increase of young loose connective tissue, permeated by many young capillaries, with the formation of new coarse membranous bone (Fig. 65). This new coarse bone replacing the old denser bone leads to an enlargement and elongation of the bones, accompanied by bending. Pathologic fracture occurs, but is not frequent and has been recorded in only isolated cases.

One of the important complications of Paget's osteitis deformans is its association with a malignant disease. Sir James Paget (39), who originally described this disease in 1876, was struck by the frequency with which malignancy occurred in the cases which he reported. Carcinoma associated with this disease is probably accidental, and, without doubt, in some cases recorded the entire skeletal changes have been due, not to Paget's disease but to metastatic carcinoma. The simulation of this form of metastatic carcinoma to Paget's disease is due to the fact that the metastases are *via* the lymphatics and hence affect the subperiosteal zone, bringing about new bone formation.

It is this same subperiosteal zone which is also the seat of new bone formation in osteitis deformans.

On the X-ray film the differential diagnosis can usually be made because metastatic carcinoma, despite the new bone formation about the lymphatic zone, always produces lytic changes in the medullary cavity, whereas this is not the rule in Paget's disease. Involvement and bowing of the tibiæ are common in Paget's disease, but rare in metastatic carcinoma, while lung metastases are absent in Paget's but occur in carcinoma.

In from 5 to 7 per cent of the cases of Paget's disease, malignancy in the form of sarcomatous change takes place in the bones affected (40). This form of sarcoma is generally periosteal in type, and may be either of the chondral or osteoblastic variety of osteogenic sarcoma.

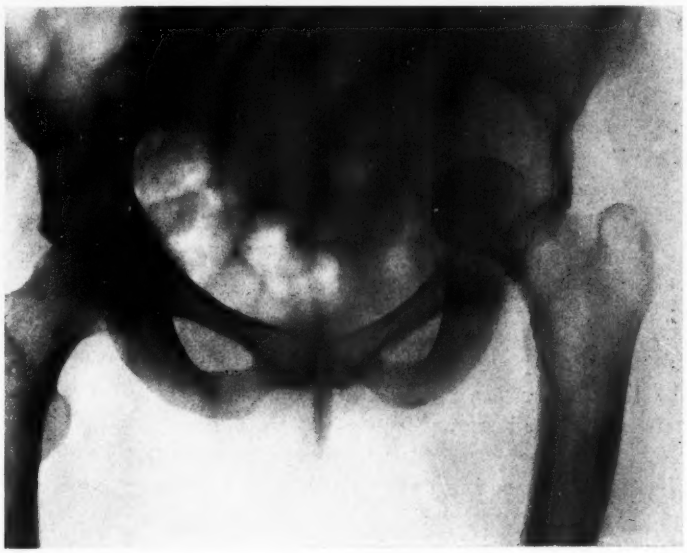


Fig. 67-*B*. Areas of metastatic bone destruction which are confluent and show a continuous zone of resorption extending from the acetabular cavity across the ilium to the sacrum.

Multiple Osteolytic Tumors in the Adult

1. Metastatic carcinoma.—Metastatic carcinoma of bone gives an extremely variable picture, since it may be either a multiple or single lesion of the skeleton and either osteolytic or osteoplastic. Nearly one-half of the lesions occur as a single focus in the end of a long bone in an adult at the point of entrance of a nutrient vessel, and produce a central area of bone destruction without much expansion of the cortex. An equal number of lesions of the metastatic type produce a diffuse multiple involvement, most frequent in the spine, pelvis, skull, and the upper ends of the long bones at the pelvic and shoulder girdles. The usual age distribution ranges from forty to eighty and is maximal at fifty-five. The bones which are most frequently affected are those of

Fig. 68-*A*. Diffuse involvement of the skeleton by metastatic carcinoma in which bone destruction is counterbalanced by new bone formation.

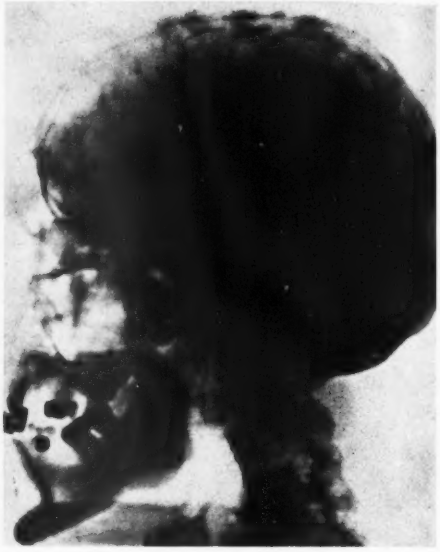


Fig. 68-*B*. Same case as shown in Figure 68-*A (which see)*.

the spine, pelvis, the femurs, and the ribs (Figs. 66-*A* and 66-*B*).

The source of these tumors is variable. The secondary tumors in the bone are usually the result of a primary carcinoma in the prostate or breast, a hypernephroma in the kidney, or malignancy in the thyroid or gastro-intestinal tract. The following list is representative, and is a tabulation from the records of cases on file in the Surgical Pathological Laboratory:

Metastatic from prostate	134
Metastatic from breast	100
Metastatic hypernephroma	22
Metastatic from gastro-intestinal tract	11
Metastatic from female genitalia	7
Metastatic from thyroid	6
Metastatic from skin	5
Metastatic from lung	4
Metastatic from biliary tract	3
Metastatic from nasopharynx	2
Metastatic from bladder	1
Metastatic from chest wall	1
Metastatic from neck	1
Metastatic from testicle	1
Undetermined source	36
Total	334

Clinically, pain of a severe rheumatic character is an important feature. When these metastatic foci localize about the spine, girdle pains and neurologic manifestations may occur. A pathologic fracture, which occurs in one-third of the cases, is often the initial symptom. From a diagnostic standpoint the knowledge or discovery of the primary tumor elsewhere in the body is most important.

The roentgenologic features of these tumors depend primarily upon whether the disease has a single focus or multiple foci, and upon whether the malignant growth is transported to the bone by a medullary route *via* the nutrient vessel or by a periosteal route *via* the lymphatics and periosteal blood vessels. If the metastases occur by the medullary route, the result is a central bone-destructive lesion and most of such lesions localize in but a single bone. If the metastases occur by the lymphatic route, new bone formation is more often stimulated and diffuse osteoplastic involvement of numerous bones, along with areas of bone necrosis, is the result.

The solitary central metastatic lesions in bone have already been discussed.

When metastatic carcinoma to bone results in a diffuse multiple involvement, the extremities about the shoulder and pelvic girdles are usually involved in association with the spine, the pelvis, and the skull. In the extremities the region near the pelvic girdle is more frequently involved than the humeri and scapulæ, and in the trunk the spine is more frequently involved than the ribs and sternum. The bones below the elbow have been involved only twice in this series of 334 cases, and the bones below the knee, including the feet, have been involved in six instances.

When the diffuse involvement is osteolytic in character the areas of destruction range from small punched-out areas, which may overlap each other like a series of rings in a chain, to large areas of destruction, which may produce bending and collapse of the bone, with pathologic fracture (Figs. 67-*A* and 67-*B*). Metastatic carcinoma from the breast is one of the most frequent forms of neoplasm in this group, giving rise to such diffuse osteolytic involvement. In the X-ray film there are usually areas of new bone formation, associated with areas of destruction, which fact aids in distinguishing these lesions from multiple myeloma, the latter producing multiple punched-out areas—usually smaller, more prone to involve the spine and ribs, associated with Bence-Jones bodies in the urine, and not showing a primary disease focus outside of the skeleton.

When the diffuse involvement is osteoplastic the bones involved usually show a combination of new bone formation and bone destruction, resulting in a widening of the bone and a decrease in bone density (Figs. 68-*A* and 68-*B*). The new bone formation gives an irregular and fuzzy appearance to the periosteal region of the bones affected. Metastatic carcinoma of the prostate is the most frequent type of lesion in this group giving rise to such osteoplastic metastases. Apparently the reason for this osteoplastic reaction in the bone is the fact that the metastases reach the skeleton through the periosteal vessels, which are identical in location with the osteogenetic regions of the bone. Metastases deposited in these regions, therefore, act as stimuli to new bone production.

The pathology of metastatic carcinoma varies according to the nature of the primary tumor. There is no proved reason that will account for the tendency of these tumors to become secondarily located in the skeleton, nor is there any adequate knowledge of the exact mode by which these growths reach the bone, although we have tried to give by inference our own interpretation for the occurrence of osteolytic lesions in one group of cases and osteoplastic lesions in another.

Metastatic carcinoma is usually a hopeless disease, but much palliative relief can be achieved by irradiation with the X-rays or with radium. We have on record instances where even metastatic melanotic carcinoma to bone has been held in check for a period of over six years, so that there is no need for the physician in charge of the case to treat it from an utterly hopeless point of view. In general, not only symptomatic relief, but actual prolongation of life—a matter of months and, rarely, of years—may be achieved by competent irradiation (41, 42).

2. Multiple myeloma.—Multiple myeloma is one of the rarest and most malignant diseases of bone. The occurrence in males is twice as frequent as in females and the age distribution resembles that of metastatic carcinoma (Figs. 69-*A* and 69-*B*), the peak of the age incidence being at fifty-five. In 425 cases reported in the literature, only two instances of this disease in patients under thirty have been recorded, one at twenty-two and one at twenty-seven. Multiple myeloma rarely presents itself

clinically as a single lesion, but is always multiple before the determination of the disease. The tumor area is always one of central bone necrosis. The six cardinal diagnostic features as described in a previous communication by the author are: (1) multiple involvement of the skeletal trunk by tumor formation in an adult over thirty-five years of age; (2) pathologic fracture of a rib; (3) the presence of Bence-Jones bodies in the urine; (4) lumbar backache, with signs of early paraplegia; (5) an otherwise inexplicable anemia, and (6) a chronic nephrosis, with nitrogen retention and low blood pressure.

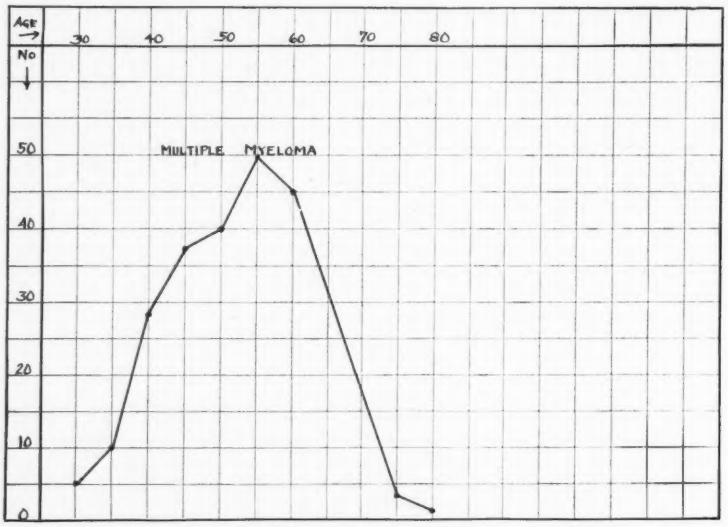


Fig. 69-*A*. Chart showing age incidence of multiple myeloma.

The typical X-ray appearance is that of multiple punched-out areas accompanied by deformity and pathologic fracture (Figs. 70-*A*, 70-*B*, 70-*C*): the latter occurs in 62 per cent of all cases. The usual involvement is in the skeletal trunk, but the skull as well as the long pipe bones about the shoulder and pelvic girdle are often affected. Diffuse involvement gives the bones a rarefied osteoporotic appearance, and in such cases, although the areas of rarefaction are generally smaller, the X-ray appearance cannot always be distinguished clinically from metastatic carcinoma. One helpful point is that multiple myeloma rarely shows chest metastasis, while this is quite frequently found in cases of metastatic carcinoma. In the skull the multiple punched-out areas are usually in the frontal and upper parietal regions. In the trunk, the spine is affected by infraction and globular areas of bone destruction, while the ribs are frequently mottled and fractured. The pelvis may become diffusely mottled and bloated in appearance. Involvement of the bones beyond the knee or elbow is rare. The microscopic picture, which is characteristic and usually of the plasma-cell type, is the last resort in diagnosis. Histogenetically, the disease originates in the bone marrow, but may metastasize to the lymph nodes, liver, and spleen (Fig. 71) (43, 44).

3. Osteomalacia and von Recklinghausen's

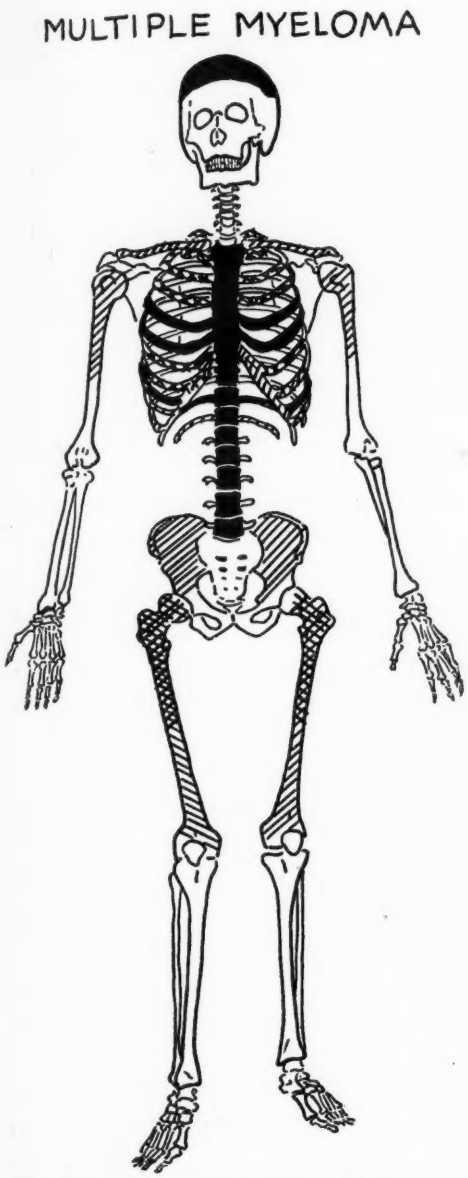


Fig. 69-*B*. Chart showing skeletal distribution of multiple myeloma. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal line areas, the occasional sites.

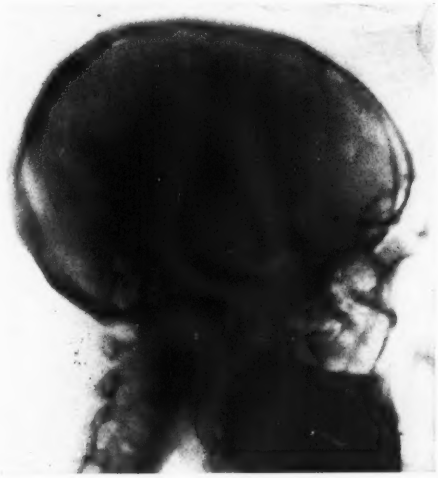


Fig. 70-*A*. Roentgenogram of the skull in multiple myeloma, showing the multiple punched-out areas in the frontal and parietal bones.

Fig. 70-*B*. Shows the involvement of the lumbar spine (same case).

disease.—A disturbance in the lime salt content of the bones leading to softening and consequent bending and deformity in an adult is referred to as osteomalacia. If the condition is associated with pregnancy in women between twenty and forty, the diagnosis is usually accepted as confirmed, but if male adults or women past the menopause are affected and multiple cysts are also present in the bones, the case is more apt to be

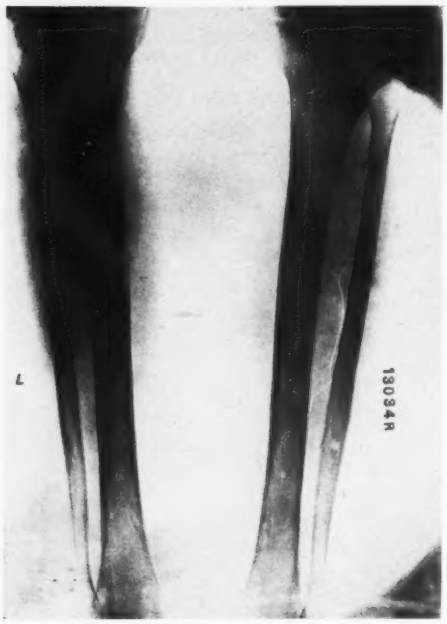


Fig. 70-*C*. Shows the classical punched-out areas of the tibiæ and fibulæ (same case).

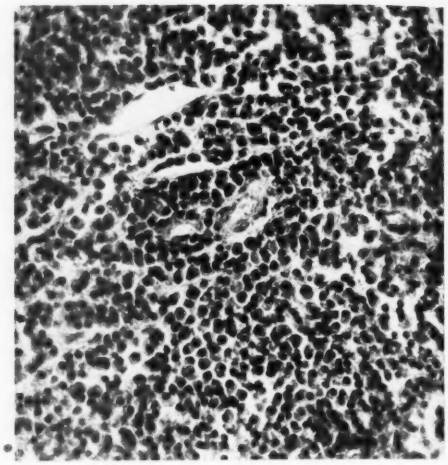


Fig. 71. Photomicrograph of the plasma cell type of multiple myeloma.

classed as von Recklinghausen's generalized osteitis fibrosa. Since solitary bone cysts need not be associated with such generalized skeletal deformities and since multiple bone cysts may occur in various types of skeletal diseases, such as Paget's osteitis deformans, fragilitas ossium, congenital syphilis, and in patients afflicted with parathyroid tumor, the description of von Recklinghausen's disease as a separate entity leads only to confusion. The cysts themselves are usually the same as those of the solitary form and their multiplicity is best attributed to the factor of the associated disease rather than to some unique and separate entity.

Multiple cysts of the bones are probably associated most frequently with osteomalacia. Although this condition is most easily recognizable in women in the childbearing age, the senile form occurs in both males and females after the age of sixty. Improvement is apt to follow the menopause in women affected during pregnancy. In progressive stages of the disease, however, pain increases with the deformities, and disability is often severe enough to keep the patient bedridden.

In the X-ray film the most characteristic appearances are the deformities which affect the thorax, pelvis, and the long bones. Compression of the pelvis is due to the weight transmitted through the femurs upward and from the spine downward. In accordance with this, the sides of the pelvis are pushed inward and the sacrum forward and downward.

In the long bones the deformities generally follow fracture and healing. The layers of compact bone are gradually absorbed until the cortex is paper-like in thinness and the entire bone is coarse, cancellous, and nearly transparent. Cysts of the osteitis fibrosa type occur in the marrow cavity, increasing the deformity and the liability to fracture. The cysts are prone to progress along the shaft of the long bones until nearly one-half of the length is involved. At times, spontaneous regression and healing take place, and we have seen such large evacuated

areas in the skull disappear without treatment (45, 46).

REFERENCES

(1) MEYERDING, HENRY W.: Exostosis. RADIOLOGY, April, 1927, VIII, 282.

(2) GESCHICKTER, C. F.: Tumors of the Fibrocartilaginous Group. To be published in Arch. Surg.

(3) PHEMISTER, D. B.: Chondrosarcoma of Bone. Surg., Gynec. and Obst., January, 1930, L, No. 1A, p. 216.

(4) KOLODNY, ANATOLE: Bone Sarcoma: The Primary Malignant Tumors of Bone and the Giant-cell Tumor. Surgical Publishing Co., Chicago 1927.

(5) COPELAND, M. M., GESCHICKTER, C. F., and BLOODGOOD, J. C.: Ewing's Sarcoma: Small Round-cell Sarcoma of Bone. Arch. Surg., February, 1930, XX, 246.

(6) CONNOR, CHARLES L.: Endothelial Myeloma, Ewing: Report of Fifty-four Cases. Arch. Surg., April, 1926, XII, 789.

(7) BLOODGOOD, JOSEPH C.: Bone Diseases: Non-suppurating Osteomyelitis (Garré): Infectious Ossifying Periostitis (Bloodgood). Jour. Radiol., August, 1922, III, 310.

(8) HENDERSON, M. S.: Chronic Sclerosing Osteitis. Jour. Am. Med. Assn., March 22, 1924, LXXXII, 945.

(9) GESCHICKTER, C. F., COPELAND, M. M., and BLOODGOOD, J. C.: Osteitis Fibrosa and Giant-cell Tumor. Arch. Surg., August, 1929, XIX, 169.

(10) SILVER, DAVID: The So-called Benign Cyst of the Bones: Report of a Case Simulating Hip-joint Disease: Review of the Literature: Bibliography. Am. Jour. Orthop. Surg., May, 1912, IX, 563.

(11) GESCHICKTER, C. F., and COPELAND, M. M.: Osteogenic Sarcoma. To be published in Arch. Surg.

(12) Idem: Recurrent and So-called Metastatic Giant-cell Tumor. Arch. Surg., May, 1930, XX, 748 (IV).

(13) HENDERSON, M. S., and SIMON, H. E.: Brodie's Abscess. Arch. Surg., November, 1924, IX (Pt. 1), 504.

(14) BRODIE, B.: Brodie's Tumor and Brodie's Abscess. British Jour. Surg., January, 1922, IX, 334.

(15) GESCHICKTER, C. F.: Chondrosarcoma of Extra-osseous Origin. Proc. Staff Meet., Mayo Clinic, May 8, 1929, IV, 147.

(16) BLOODGOOD, JOSEPH C.: Bone Tumors: Myxoma, Central, and Periosteal: Their Recurrence after Exploratory Excision and Piecemeal Removal. Ann. Surg., December, 1920, LXXII, 712.

(17) STARR, CLARENCE L.: Osteomyelitis. Practice of Surgery (Dean Lewis), Vol. II, Chap. II. W. F. Prior Co., Inc., Hagerstown, Md., 1929.

(18) ALLISON, NATHANIEL: Arthropathy. Practice of Surgery (Dean Lewis), Vol. II, Chap. VI. W. F. Prior Co., Inc., Hagerstown, Md., 1929.

(19) LINDSAY, JANVIER W., RICE, E. CLARENCE, and SELINGER, MAURICE A.: Bone Changes in Congenital Syphilis. Am. Jour. Syphilis, January, 1927, XI, 118.

(20) DILLINGHAM, FREDERICK H., and MCCAFFERTY, LAWRENCE K.: Bone Syphilis. Am. Jour. Syphilis, July, 1926, X, 373.

(21) EWING, JAMES: Neoplastic Diseases: A Treatise on Tumors. Third Ed., p. 296. W. B. Saunders Co., Philadelphia and London, 1928.

(22) BLOODGOOD, JOSEPH C.: The Diagnosis and Treatment of Benign and Malignant Tumors of Bone. Jour. Radiol., March, 1920, I, 147.

(23) PAUL, JOHN R.: Case of Periosteal Fibroma Followed by Progressive Myositis Ossificans. Proc. Path. Soc. Phila., 1923-24, XXVI, 89.
KÜTTNER, HERMANN: Die Myositis ossificans circumscripta. Ergebn. d. Chir. u. Orthopädie, 1910, I, 49.

(24) COLEY, WILLIAM B.: Myositis Ossificans Traumatica: A Report of Three Cases Illustrating the Difficulties of Diagnosis from Sarcoma. Ann. Surg., March, 1913, LVII, 305.

(25) STEWART, M. J.: The Histogenesis of Myeloid Sarcoma. Lancet, Nov. 25, 1922, II, 1106.

(26) HERENDEEN, R. E.: Giant-cell Tumors of Bone, with Special Reference to Treatment Technic. Am. Jour. Surg., January, 1930, VIII, 122.

(27) KEILLER, V. H.: Cartilaginous Tumors of Bone. Surg., Gynec. and Obst., April, 1925, XL, 510.

(28) BLOODGOOD, JOSEPH C.: Bone Tumors. Am. Jour. Orthop. Surg., November, 1920, II, 597.

(29) COPELAND, M. M.: Skeletal Metastasis of Epithelial and Connective Tissue Origin. To be published in Ann. Surg.

(30) BLOODGOOD, J. C.: Central Bone Tumors and Their Differential Diagnosis. Minnesota Med., October, 1922, V, 604.

(31) GESCHICKTER, C. F.: Multiple Myeloma as a Single Lesion. Ann. Surg., 1930, XCL, 425.

(32) EHRENFRIED, ALBERT: Hereditary Deforming Chondrodysplasia — Multiple Cartilaginous Exostoses: A Review of the American Literature and Report of Twelve Cases. Jour. Am. Med. Assn., Feb. 17, 1917, LXVIII, 502.

(33) JANSEN, MURK: Dissociation of Bone Growth (Exostoses and Enchondromata, or Ollier's Dyschrondroplasia and Associated Phenomena). Robert Jones Birthday Volume, p. 43. Oxford Univ. Press, London, 1928.

(34) REICHE, F.: Osteosklerose und Anämie. Münch. med. Wchnschr., July 13, 1915, LXII, No. 28, p. 944.

(35) DAVIS, GEORGE G.: Osteosclerosis Fragilis Generalisata: Marmorknochen: Albers-Schönberg Disease. Arch. Surg., November, 1922, V, 449.

(36) TRENDEL: Beiträge zur Kenntnis der akuten infektiösen Osteomyelitis und ihrer Folgeerscheinungen. Bruns' Beiträge z. klin. Chir., 1904, XLI, 607.

(37) KNAGGS, ROBERT LAWFORD: The inflammatory and Toxic Diseases of Bone: A Text-book for Senior Students, p. 375. William Wood and Co., New York, 1926.

(38) KEY, J. ALBERT: Brittle Bones and Blue Sclera: Hereditary Hypoplasia of the Mesenchyme. Arch. Surg., October, 1926, XIII, 523.

(39) PAGET, SIR JAMES: On a Form of Chronic Inflammation of Bones (Osteitis Deformans). Medico-Chirurgical Trans., 1877, LX, 37.

(40) HURWITZ, S. H.: Osteitis Deformans, Paget's Disease: A Report of Six Cases Occurring in the Johns Hopkins Hospital and Dispensary. Johns Hopkins Hosp. Bull., September, 1913, XXIV, 263.

(41) JOLL, C. A.: Metastatic Tumors of Bone. British Jour. Surg., July, 1923, XI, 38.

(42) PINEY, A.: Carcinoma of Bone-marrow. British Jour. Surg., October, 1922, X, 235.

(43) GESCHICKTER, C. F., and COPELAND, M. M.: Multiple Myeloma. Arch. Surg., April, 1928, XVI, 807.

(44) MEYERDING, HENRY W.: Multiple Myeloma. RADIOLOGY, August, 1925, V, 132.

(45) KNAGGS, ROBERT LAWFORD: The Inflammatory and Toxic Diseases of Bone: A Text-book for Senior Students, p. 268. William Wood and Co., New York, 1926.

(46) VON RECKLINGHAUSEN, FRIEDRICH D.: Die fibröse oder deformirende Ostitis, die Osteomalacie und die osteoplastiche Carcinose in ihren gegenseitigen Beziehungen. Festschr. Rudolf Virchow, 1891.

LESIONS OF THE CLAVICLE

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THE clavicle is classified as one of the smaller bones of the skeletal framework and is very seldom heard of in tumor pathology. However, under a systematic review of the skeletal lesions on file in the Surgical Pathological Laboratory of the Johns Hopkins Medical School, we find that there are lesions of all kinds present in the clavicle as elsewhere in other bones.

As for the anatomy of the clavicle, it is well to recall the peculiar S-shape of the bone which articulates with the sternum and the acromion process of the scapula, forming the mainstay of the shoulder girdle. The sternal end articulates with the sternum by means of the intervention of fibro-cartilaginous discs, while the acromial end articulates directly. The structure of the clavicle is peculiar in that it is made up entirely of cancellous bone with a dense cortical covering, there being no medullary cavity. The ossification in this bone is also of interest as it is the first bone in the body to show signs of ossification and the last to become ossified, since the secondary ossification which is located at the sternal end does not join the main body until after the twenty-fifth year. Whether these peculiarities have any importance may be seen in the following discussion.

Lesions of the clavicle are easily recognized but difficult to diagnose and to treat correctly. The clavicle is a superficial bone and may be palpated easily over its whole course, any abnormality being easily recognized by the evident deformity produced. Fractured clavicles are easily picked out by the deformity due to displacement of fractured ends of the bones and by the characteristic drooping of the shoulder. Any abnormal swellings are easily seen; however, the X-ray appearance is very vague and often confusing, due to the interference of the chest structures and numerous other bones in close proximity. Well-defined and clear films are not easily obtained. Also, in regard to common diseases such as syphilis, gonorrheal arthritis, and cartilaginous tumors, which are so frequently found in the region of the sternal joint, the X-ray appearance is very indefinite, and in this site a most careful history should be taken concerning venereal diseases. One such case completely baffled a well-known clinic until anti-syphilitic treatment was recommended on the basis of a syphilitic history and ultimately the tumor disappeared. Biopsy in this region is of value, but, again, biopsy should not be resorted to without preparation for radical treatment, and radical treatment in the region of the clavicle is a rather mutilating and serious operation.

In the study presented here we find that of 1,700 bone lesions on record in the Laboratory there were 41 lesions located in the clavicle. They are recorded and classified as follows:

TABLE I

Type of lesion	Total skeletal lesions	Clavicular lesions
Periostitis	100	7
Exostosis	262	2
Chondroma	75	1
Bone cyst	175	4
Giant-cell tumor	226	1
Chondroblastoma	21	1
Osteogenic sarcoma	170	1
Sclerosing sarcoma	80	1
Ewing's sarcoma	70	4
Multiple myeloma	20	8
Metastatic carcinoma	310	16

In the discussion of these tumors in the order as recorded above, we shall take into consideration the clinical picture, X-ray

findings, treatment, and results as far as it has been possible to obtain them.

NON-SUPPURATIVE PERIOSTITIS

This type of lesion showed in our series seven cases, or 7 per cent of the total number of similar lesions found in other bones and discussed thoroughly by Dr. L. C. Cohn from the same laboratory. Five of the seven cases were found in females. One of the seven cases was of a multiple type. The duration of symptoms averaged from six to forty-eight months. Three patients of the group gave a history of tumor, while four gave a history of pain localized in the bone and associated with swelling. Five patients gave a syphilitic history, while only one had the etiology of trauma. The X-ray film showed both bone destruction and sclerosis in most instances, while in two it showed sclerosis or destruction alone. This goes to prove that the X-ray findings are rather variable and may lead to a confused diagnosis. According to the follow-up notes, the five cases with syphilitic history were given anti-syphilitic treatment and three cases were reported as cured ranging over a period of from two to eleven years. One of these cases had a biopsy performed, and microscopical examination revealed only an infected granulation tissue.

EXOSTOSIS

According to its definition this is a bony growth projecting out from the surface of a normal bone. There were but two of these cases found in our series, and in both of them the X-ray examination showed a rounded exostosis, with no pedicle present. One case gave a syphilitic history and on a more careful examination revealed a multiple type of lesion. This is one of the cases which cleared up under anti-syphilitic treatment. The second case was that of a boy, aged eleven years, who gave a history of trauma, the tumor having been present for one year. No biopsy was performed but resection was carried out in May, 1910, and the patient is well at the present time—January, 1930—twenty years later.

CHONDROMAS

Chondromas or cartilaginous tumors usually arise in areas of normal cartilage. We present here only one case, that of a white female, aged twenty-six years, who gave a history of pain and tumor in the sternoclavicular joint, with a duration of symptoms of fourteen years. The tumor was excised in 1926 and pathologic sections showed normal cartilage cells, the final diagnosis being hypertrophied joint cartilage.

BONE CYSTS

In discussing bone cysts we must take into consideration the epiphysis, as in long bones. The epiphysis in the clavicle is located at the sternal end and does not ossify until after the age of twenty-five years. According to statistical study, the age incidence is between five and eighteen years, the latter being the upper limit except for an occasional latent tumor which may occur in later life and go undiagnosed. In our series of four cases the age incidence ranged 7, 17, 49, and 72, respectively. The location of the first three was at the sternal end, while the fourth case showed multiple cysts at the acromial end. This, again, brings up for consideration the idea of Geschickter and Copeland, who state that bone cysts are healed giant-cell tumors, progressing farther and farther down the shaft from the epiphysis according to the growth of the bone. In the last case mentioned, tumor and pain had been present for about fifty years, while in the other cases symptoms had been present not longer than six months. The X-ray film in each case, although indefinite and vague, showed a central lesion, with definite

cystic expansion of a bony shell. Two cases were curetted and sections showed a typical fibrous tissue lining, diagnosed as osteitis fibrosa. The ultimate results of the two curetted cases showed the patients to be well five and six years, respectively, while the two cases that were not operated upon were well three and seven years, respectively.

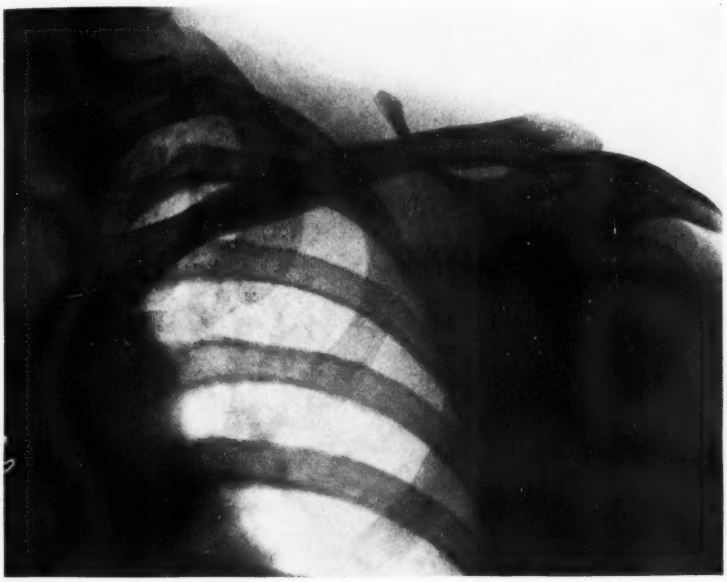

Fig. 1. Widening and sclerosis of the shaft of the clavicle due to syphilitic periostitis.

GIANT-CELL TUMOR

Giant-cell tumor is a lesion usually described as being located in the epiphyseal region of a long bone, as compared to a bone cyst, which arises in the shaft. Although the clavicle is a superficial bone and exposed to trauma rather frequently, nevertheless it is a rare location for giant-cell tumors. In our one and only case as compared to 226 cases on record, the age incidence does not compare with that usually ascribed as over eighteen years of age. The case under discussion was that of a white male, aged eleven years, who had had a tumor located in the region of the junction of the clavicle and the first rib. The duration was nine months. The clavicle and first rib were resected and microscopic examination revealed a typical picture of a giant-cell tumor, namely, a dense stroma made up of a fibrous tissue and cells containing round nuclei. Scattered throughout the matrix were numerous giant cells of the epulis type, whose nuclei corresponded in size and shape to those contained in the surrounding matrix. No signs of malignancy were found. The patient was reported as well in 1928—fourteen years later.

SARCOMA

Malignant tumors of the clavicle are also rare. The sarcomatous lesions represented in our series are the chondroblastic and the sclerosing type of osteogenic sarcoma and Ewing's round-cell sarcoma.

One case diagnosed as a chondroblastoma occurred in a white male, aged thirty-two years, who had had pain and tumor in the region of the second rib and clavicle for six months. The X-ray film showed a lesion of a destructive nature which was deemed inoperable. Coley's serum treatment was instigated but the patient died four months later. No tissue was obtained and the diagnosis was made from the X-ray film and history alone.

Fig. 2. Expansion of the sternal end of the clavicle, with rarefaction, due to a benign bone cyst.

The second case of sarcoma was that of a white male, aged fifteen, who gave a history of trauma, pain, and tumor in the midclavicle for three months. The X-ray examination showed a sclerosing periosteal lesion, with slight bone destruction. The tumor was excised, followed by post-operative X-ray treatment. Microscopic examination revealed definite new bone formation, with osteoblasts and fibro-spindle cells. The ultimate result showed the patient well ten years later.

In the discussion of sarcoma we must take into consideration Ewing's round-cell sarcoma. There were 70 cases of this type of lesion of the whole skeleton, two of which were located in the clavicle. The general location of these tumors may be seen in Table II.

TABLE II

Location	Total number
Tibia	15
Femur	13
Humerus	7
Fibula	8
Radius	1
Ribs	1
Pelvis	5
Scapula	4
Clavicle	2
Metatarsal	2
Tarsal	1
Skull	1

Our two cases under discussion had tumor and pain. X-ray examination revealed a diffuse involvement, with bone destruction. The treatment of the cases was as follows: *Case 1.*—Excision of scapula and outer end

of clavicle in 1920; excision of remainder of clavicle and radium treatment in 1921.

Case 2.—Resection performed in 1919; ex-

Fig. 3. Expansion of areas of destruction and bone formation in a healed bone cyst in the outer end of the clavicle.

cision of recurrence in 1920, followed by X-ray treatments. Both cases showed a microscopic picture of small round cells, with clear-cut nuclei and fibrous stroma, as described by Geschickter and Copeland. Our follow-up system showed that the first case mentioned was well nine years later, while the second case was reported well seven years and three months later.

In the examination of the other Ewing's tumors we find that metastasis is of rather common occurrence: of a series of 25 cases out of a possible 70 showing metastases to other bones, only one case with a primary lesion in the lower tibia showed dissemination to the clavicle and scapula.

The origin of Ewing's tumors is ascribed by some authors to the medullary cavity and by others to a subperiosteal growth. It should be remembered that the clavicle has no medullary cavity.

MULTIPLE MYELOMA

Tumors of the multiple myeloma group, as understood from the name, have multiple foci. They give the usual symptoms of pain, swelling, and gradually developing deformity, with fracture. The X-ray appearance is that of a moth-eaten bony structure, so that one can easily see why fractures are so prevalent. The microscopic picture when biopsy is performed is that of a round-cell tumor. The cells are of a plasma type with a nucleus, the chromatin of which has a somewhat spoke-like manner of grouping. Bence-Jones bodies are diagnostic but not an absolute proof.

METASTATIC TUMORS

The largest series of clavicular lesions are found in this group. Of 310 cases of metastases to bone, 16 cases had lesions located in the clavicle, being of either a single or multiple focus. Six cases showed lesions

only in the clavicle, while ten had lesions in other bones as well.

In Table III are found the type of lesions metastasizing to bone and the number occurring in the clavicle.

TABLE III

Primary tumor	Total number	Number in clavicle
Hypernephroma	22	0
Prostate	110	0
Testicle	2	0
Bladder	1	0
Uterus	6	0
Sarcoma (ovary)	1	0
Carcinoma (stomach)	7	0
Carcinoma (lung)	4	0
Malignant pigmented mole	3	1
Adenoid cystic carcinoma	1	1
Carcinoma of heel and ear	1	0
Sarcoma of soft parts	2	2
Breast carcinoma	100	4
Undetermined origin	36	8

We can see from this tabulation that metastatic tumors in a sense are rather rare, but as 16 cases were found in a group of this sort and a primary lesion discovered, a mutilating operation could easily be avoided by withholding surgery for X-ray and radium. One of our cases had resection performed, while another had the Coley serum treatment. Palliative treatment is practically the only measure advocated, duration of life after the first signs being from eight to thirty months.

Two of the cases in this series occurred with sarcoma of the soft tissues of the neck. These probably invaded the neck by direct extension, as it is of rather rare occurrence for sarcomatous lesions to metastasize to bones.

One case of special interest is that of a man aged 67, who had a polypoid mass removed from the region of the nose. Section showed what was diagnosed as an adenoid cystic carcinoma of the basal-cell type. The patient was discharged, only to return about six months later with a pain in the region of the right clavicle, with a recent pathologic fracture. The X-ray study showed a diffuse skeletal lesion involving the skull, cervical vertebræ, clavicles, scapulas, and ribs. A diagnosis of multiple myeloma was made and biopsy was performed. Microscopic examination revealed a picture similar to that of the primary lesion removed from the nose. The patient survived about thirty-six months after the first operation.

DIFFERENTIAL DIAGNOSIS

How to diagnose and differentiate these tumors is a most unsatisfactory and difficult subject to discuss. A patient presenting himself with pain in the clavicular region should be questioned carefully as to trauma and venereal diseases. The physical examination should be thorough as regards the bone involvement and other skeletal lesions. X-ray studies of both clavicles should be carried out, and, if any suspicious areas are found, X-ray films of the chest, skull, pelvis, and long bones should be made and examined for multiple lesions. The X-ray study and the history, although probably difficult to interpret, are of great importance. Biopsy should not be carried out unless there is provision for definite and final diagnosis from the microscopic sections. If in doubt, provocative treatment with arsphenamine may be tried with hopeful results in many so-called single lesions. For multiple lesions the primary source should be searched for and thorough X-ray or radium treatment started.

As for the majority of the single lesions, the age incidence of bone cysts and giant-cell tumors, which is under that of most malignant lesions in this locality, should be taken into account.

NON-SUPPURATIVE OSTEOMYELITIS

By L. CLARENCE COHN, M.D., BALTIMORE, MARYLAND

From the Surgical Pathological Laboratory of the Johns Hopkins University

LESIONS of bone without suppuration most frequently cause the greatest difficulty in diagnosis. Both in sarcoma of bone and in the benign lesions of bone which in the roentgenogram resemble sarcoma, changes in the normal bone have taken place which produce changes in the X-ray characteristic of sclerosis, ossification, destruction, and osteoporosis.

Baker[1] in 1877 published a personal observation of a case of necrosis of the femur, without suppuration, in which the differential diagnosis from sarcoma was not established until the gross and microscopic studies were made following amputation. In this case there was a pathologic fracture. This was before the use of the X-ray.

Klemm,[2] from the clinic of Professor Garré, writing on the gross pathology of sclerosing non-suppurative osteomyelitis, calls attention to the fact that sclerosis takes place at the border of the lytic zone where the infectious irritation no longer is sufficient to destroy the bone, and that a circumscribed marrow suppuration may remain latent, the disease picture being governed by the reactive tendency of the bone, the virulence of the organism remaining constant whether extensive suppuration is present or absent.

To-day even with the aid of the roentgenogram the differential diagnosis of non-suppurative osteomyelitis from sarcoma is becoming more and more difficult, because chronic osteomyelitis is coming under observation before the stage of suppuration so much more frequently and in a stage in which the changes produced in the roentgenogram are similar to the changes produced by sarcoma. From 1889 to 1900 we had no cases of non-suppurative osteomyelitis recorded in this clinic; from 1900 to 1910 only three cases; in the decade from 1910 to 1920, twenty-one cases, and from 1920 to 1930, eighty-one cases. Sarcoma of bone is now coming under observation so early that the most experienced roentgenologists and clinicians, and even the surgeons

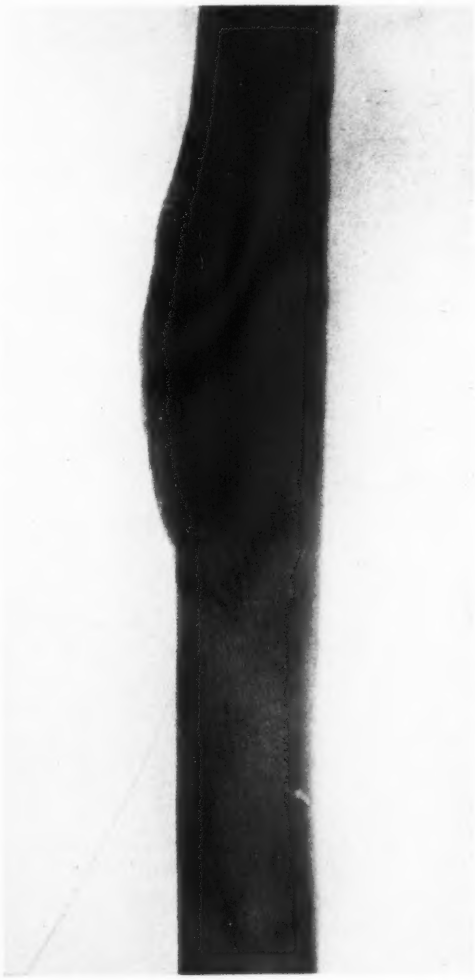

Fig. 1. Subperiosteal ossifying type of non-suppurative osteomyelitis in shaft of femur.

[1]W. Morant Baker, Med.-Chir. Trans., LX.
[2]Paul Klemm, Beitr. z. klin. Chir., 1912, pp. 54-72.

Fig. 2. Marked ossification of head, neck, and shaft of humerus; pseudo-bone destruction. History of trauma.

Fig. 3. Marked ossification. Sections showed chondrosarcoma. Amputation. The patient has been well for nine months.

and pathologists most highly trained in the diagnosis of bone lesions, are unable to make this differential diagnosis in many instances until the microscropic section is studied.

Prior to 1876, when Sir James Paget[3] read before the Medical-Chirurgical Faculty of London his epoch-making paper on osteitis deformans, this disease also was included in the heterogeneous group of non-suppurating benign lesions of bone. The publication of Klemm's article, referred to above, again tended to clarify the atmosphere by calling attention to what is now known as the sclerosing non-suppurative osteomyelitis of Garré.

In this present study of 105 cases of non-suppurative benign lesions of bone grouped in the laboratory under Paget's disease, ossifying periostitis, and non-suppurating osteomyelitis, we are attempting a classification on the basis of the changes produced in the roentgenogram and on etiology. We are including Paget's disease along with the other types of non-suppurative osteomyelitis, because at certain periods in the life history of this disease we are confronted with roentgenograms which simulate certain other types of non-suppurative osteomyelitis

[3]Sir James Paget, Trans. Royal Med.-Chir. Soc., 1877, LX, 37-63.

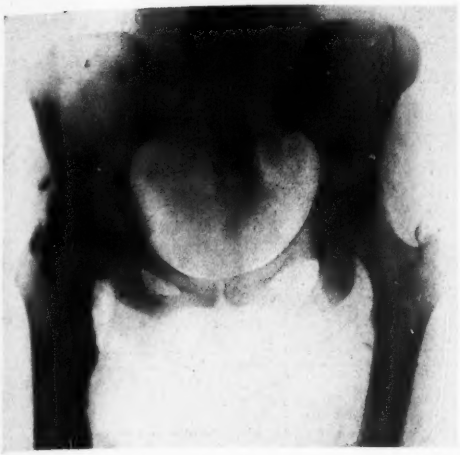

Fig. 4. Marked ossification of shaft and epiphysis of femur, never, in our experience, associated with sarcoma.

and it is quite possible that the same etiologic factors prevail. At the same time, we

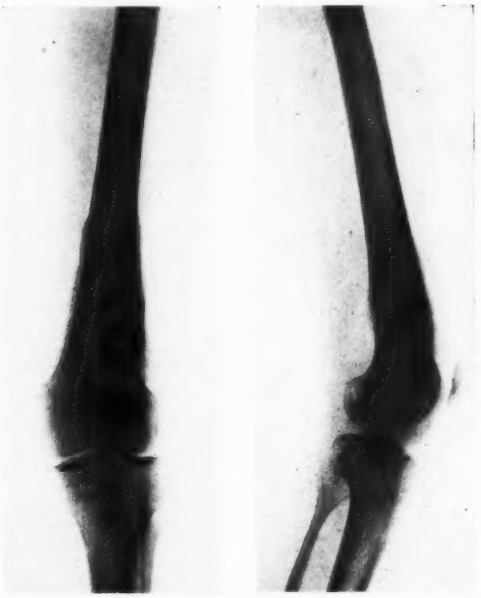

Fig. 6. Ossifying and sclerosing type of non-suppurating osteomyelitis, to be differentiated from sarcoma. Biopsy only. The patient has been well for five years. (For photomicrograph see Fig. 13.)

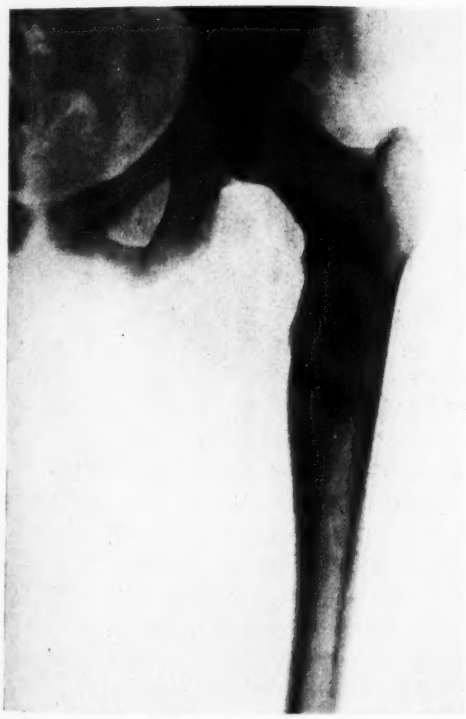

Fig. 5. Sclerosing type of non-suppurating osteomyelitis, to be differentiated from sclerosing sarcoma.

are aware that Paget's disease over a period of years produces certain characteristic changes in the skeleton which do not occur in the other types. It is very helpful in studying an unknown bone lesion to first decide whether the changes appearing in the roentgenograms are due to ossification, destruction, sclerosis, or osteoporosis. From the changes produced in the roentgenogram we have classified non-suppurative osteomyelitis into four groups: sclerosing, ossifying, destructive, and osteoporotic. For the purposes of comparison when attempting to make the differential diagnosis one must bear in mind sarcoma, which may be classified into the same four groups. From the etiologic standpoint we have classified non-suppurative osteomyelitis into four groups: traumatic, syphilitic, post-typhoid, or post-influenzal, etc., and infectious from foci of infection. The classification of non-sup-

Fig. 7. Diagnosed sarcoma from X-ray examination and microscopic section. The patient, who refused amputation, had been well for eight years when last heard from in 1922. (For photomicrograph see Fig. 14.)

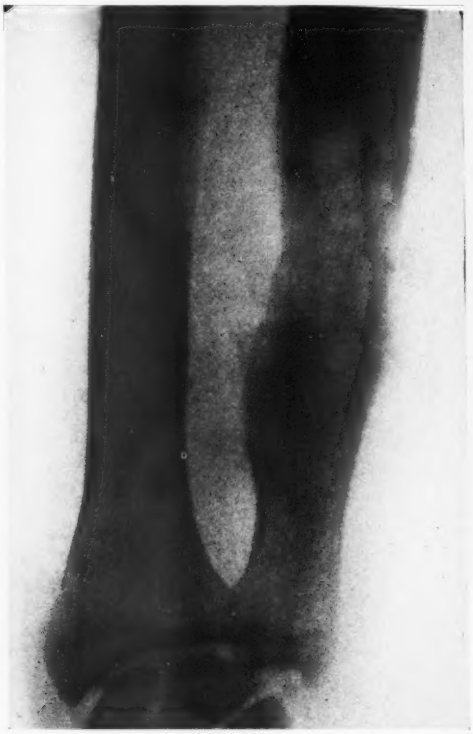

Fig. 8. Destructive type of non-suppurative osteomyelitis. Wassermann plus. To be differentiated from destructive sarcoma. (For photomicrograph see Fig. 16.)

purative osteomyelitis then would read as follows:

NON-SUPPURATIVE OSTEOMYELITIS

1. Sclerosing	*(a)* Traumatic
2. Ossifying	*(b)* Syphilitic
3. Destructive	*(c)* Post-typhoid or post-influenza, etc.
4. Osteoporotic	*(d)* Infectious from distant focus

CLINICAL HISTORY

Non-suppurative osteomyelitis, like sarcoma of bone, is frequently a disease of youth and middle age. By far the greater number of cases in this group came under observation while under forty years of age (75 per cent), and 33 per cent were under twenty. This about coincides with the age incidence in sarcoma of bone. Again, about 25 per cent of the patients came under observation when the disease had been present about three years. The majority of patients with sarcoma of bone, without treatment, have died within this length of time. Seventy-five per cent came under observation at a period when the disease had a duration of from a few weeks to three years, and about half (50 per cent) came under observation when the disease had been present less than one year. It seems that in the future this group will materially

increase, and it is this group which offers the greatest difficulty in diagnosis.

When we study the symptoms of onset we find fracture six times and we know that fracture is rarely followed by malignant changes in bone unless the disease has been present before the fracture. Bloodgood has emphasized for years the importance of an X-ray examination after an injury, even though fracture is unsuspected, in order to determine graphically the condition of the bone at the time of the injury. We will speak of trauma later when discussing etiology. With the exception of these six cases in which fracture was a symptom of onset, either pain, swelling, deformity, or limitation of motion was the symptom of onset in practically every case.

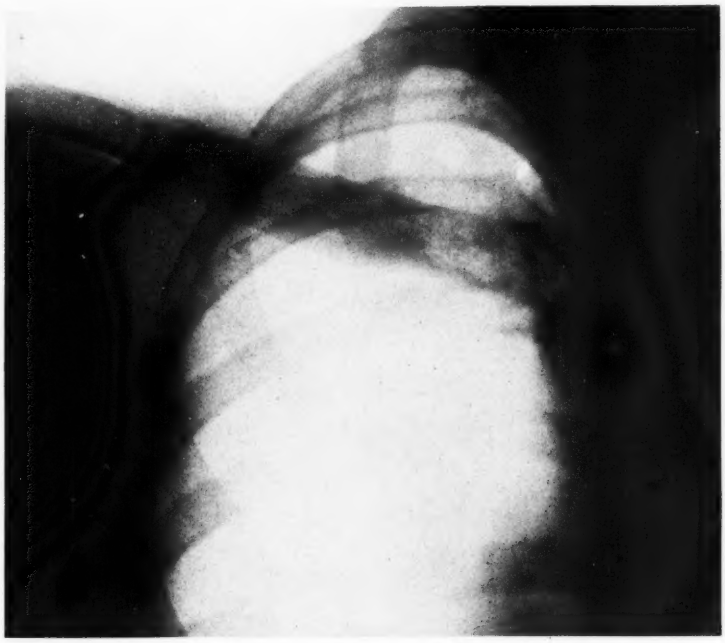

Fig. 9. Destructive type of non-suppurating osteomyelitis of the clavicle. Wassermann plus. The patient has been well for eight years following antisyphilitic treatment only.

ETIOLOGY

Under the heading of etiology we are going to consider trauma, syphilis, focal infections, and those cases which followed shortly after a general infection such as typhoid fever, influenza, or acute rheumatic fever. There is a note on trauma in forty-seven instances, but in the history of the majority of cases the fundamental point of the time factor between trauma and symptom of onset is not noted. Trauma was present, therefore, in almost 50 per cent of the cases. In studying the actual X-rays of the entire group trauma is present quite as frequently in the ossifying as in the sclerosing type. It is notable by its absence in the destructive type except in one instance, when it was associated with a posi-

tive Wassermann. In the osteoporotic type the frequency of trauma is perhaps a little less than in the ossifying or sclerosing type.

The Wassermann was plus in eleven instances (10 per cent), and about equally distributed among the four types. There is sometimes an impression that a plus Wassermann is more likely to be associated with the destructive type of non-suppurative osteomyelitis, and I wish to call attention here to the frequent association of syphilis with the ossifying type—syphilitic ossifying periostitis.

The frequency of demonstrable focal infection was about the same as syphilis (10 per cent). The earlier cases were incompletely studied from this angle, and recently this group has been coming more to the front. There were six cases (only about 5 per cent), which followed typhoid fever,

Fig. 10. Localized osteoporosis in epiphysis and shaft of humerus in a patient with multiple lesions of bone. Wassermann positive.

influenza, or rheumatic fever, and in one case there was a lesion of the femur which on the X-ray film looked like sarcoma.

MULTIPLE LESIONS

More than one bone was involved in about 25 per cent of the cases, and the lesion was single in about 75 per cent. When dealing with a multiple disease of bone one thinks of Paget's disease, syphilitic, non-suppurative osteomyelitis, metastatic carcinoma or hypernephroma, and multiple myeloma, rather than of a multiple primary sarcoma, but in three instances there are recorded in the laboratory sarcoma of bone arising in Paget's disease in which there was multiple involvement of the skeleton. Paget's original case with multiple involvement of the skeleton developed sarcoma of the radius. Therefore multiplicity of the lesion does not entirely rule out sarcoma.

BONE INVOLVED

The tibia and the femur are each involved in about 20 per cent of the cases; the humerus in about 8 per cent; the pelvis in about 5 per cent; the skull in about 5 per cent, and the clavicle in about 5 per cent. The remaining 35 per cent includes lesions of the radius, ulna, fibula, metatarsal and metacarpal, carpal and tarsal bones, phalanges, ribs, vertebræ, and jaw. The jaw, tarsal and carpal bones are least frequently involved.

X-RAY RESEMBLANCE TO SARCOMA

One asks the question, "How often does the X-ray appearance of non-suppurative osteomyelitis resemble the X-ray appearance of sarcoma?" In 66 per cent of the cases we felt from the X-ray examination alone that we were dealing with a benign lesion, and that there was a question as to sarcoma in about 33 per cent.

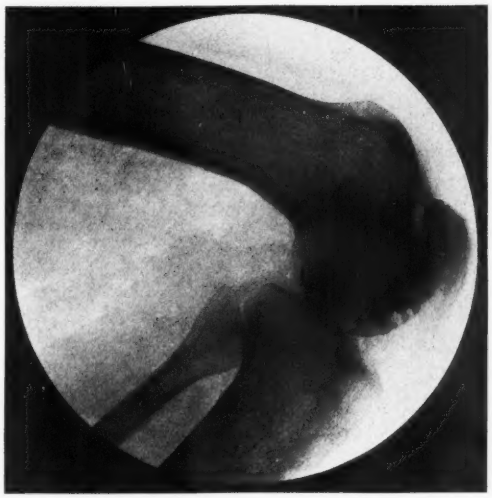

Fig. 11. Localized osteoporosis in epiphysis and shaft of femur. Sections showed myxoma. Amputation. Death in 1930 from metastasis six years after amputation.

X-RAY APPEARANCE OF THE OSSIFYING TYPE

On the X-ray film the area of ossification or of new bone formation may vary from the congenital spur, in the shape of a horn attached to a normal shaft (type of congenital exostosis), to the mushroom-like pedunculated exostosis sometimes associated with fracture, occasionally seen in riders' bone, attached to the pelvis. The area of ossification may vary from the large irregular mass of new bone attached to a normal shaft throughout its entire base, presenting the picture of ossifying myositis becoming secondarily attached to the shaft, to an area of ossification beneath the periosteum, producing subperiosteal localized ossification (Fig. 1). When there is a large area of bone formation completely surrounding the shaft of the bone, casting irregular shadows over the shaft and producing the picture of pseudo-bone destruction, there is always difficulty in diagnosis. We have an instance of this type (see Fig. 2) in a case of the ossifying type of non-suppurative osteomyelitis. The patient was a man aged

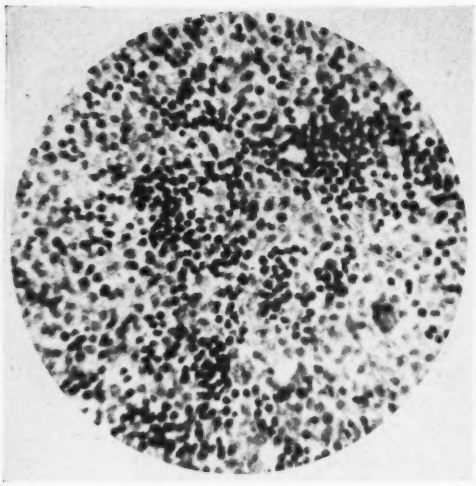

Fig. 12. High-power photomicrograph of necrotic bone with granulation tissue in which plasma cells predominate.

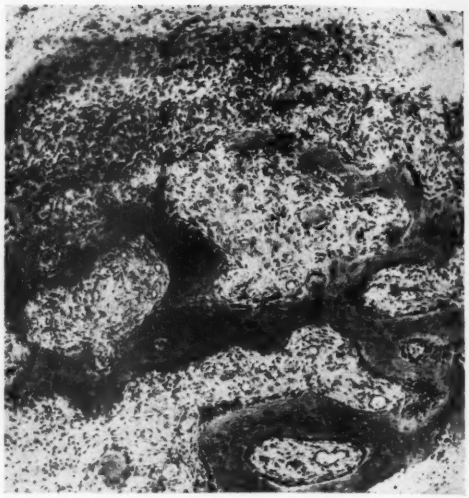

Fig. 13. Photomicrograph of specimen shown in Figure 6. Compact bone with enlarged haversian canals, fibrous stroma, and small capillaries.

thirty-eight, the lesion following trauma two years and again four months previous to initial examination. There was no operation and no increase in size or symptoms one year later when last heard from. This case should be compared to the case shown in Figure 3, diagnosed sarcoma in the X-ray film. Amputation was later done for sarcoma, following which the patient has been well for nine months. In rare instances we have seen extensive ossification extending the entire length of the shaft of a long bone (Fig. 4). When this occurs it is as pathognomonic of a benign lesion as the horn-shaped pedunculated exostosis. Ossification about a bone or joint of the hand or foot is practically always benign.

It has been emphasized again and again in the literature, and it seems unnecessary to mention it now, that it is unwise to operate on these bone lesions characterized by excessive bone formation during the formative stage, as the operative trauma invariably accelerates bone formation. The only exception to this rule should be the exploratory operation for diagnosis when sarcoma is suspected, and in these instances the surgeon must be prepared, if the lesion is malignant, to procede with the complete operation—resection or amputation—immediately, basing his diagnosis on the frozen section. Later on we will discuss the indications for radiation.

SCLEROSING TYPE

The sclerosing type of non-suppurative osteomyelitis in the roentgenogram may be pure sclerosing, combined sclerosing and ossifying, or sclerosing and destructive. This statement also holds good for sarcoma. When in the roentgenogram sclerosis predominates, as shown in Figure 5, the diagnosis is much more difficult than when we have sclerosis combined with ossification, as shown in Figure 6. The most difficult of all X-ray appearances to interpret is the case in which we have sclerosis combined with destruction. In Figure 7 is shown a case in which the diagnosis of sarcoma was made from the X-ray examination and sections, and in which amputation was refused, a biopsy only being done. The patient was well eight years later when last heard from in 1922. It is well to emphasize here the importance of making X-ray films of the

Fig. 14. Low-power photomicrograph, showing remains of haversian canals with granulation tissue of the round- and spindle-cell type; difficult to distinguish from sarcoma.

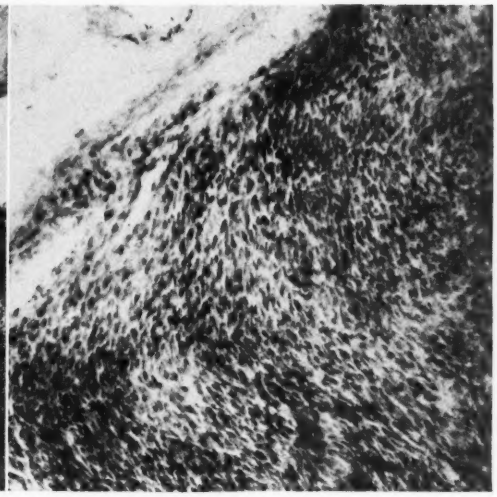

Fig. 15. High-power photomicrograph of section shown in Figure 14.

involved bone at several angles in order to give a more accurate idea of the predominance of the pathologic process which is taking place.

BONE-DESTRUCTIVE TYPE

Destruction of bone in non-suppurative osteomyelitis may be just as extensive as in destructive sarcoma (Fig. 16), and may even go on to the stage of pathologic fracture. In Figure 9 is shown a destructive lesion of the clavicle in which the Wassermann was positive. The patient has now been well for eight years, following antisyphilitic treatment. However, the destructive type of non-suppurative osteomyelitis has not always syphilis as an etiologic factor.

OSTEOPOROTIC TYPE

Localized osteoporosis is more likely to be associated with syphilis as an etiologic factor (Fig. 10), or with Paget's disease. If none of these factors can be demonstrated, it is suggestive that we are dealing with the osteoporotic type of sarcoma or myxoma or with metastatic carcinoma.

STUDY OF BONE LESIONS

In working out the diagnosis of a bone lesion there are certain routine systematic studies that must be made. These studies should include a careful clinical history, in which there must be a definite statement as to the presence or absence of trauma; a note on previous systemic infectious diseases; the presence or absence of focal infections, carbuncles, and boils. There should be a careful examination of the nose, throat, ears, and paranasal sinuses. The blood examination should include the leukocyte count, total and differential. The evening rectal temperature is important. The examination of the urine for Bence-Jones bodies and the blood Wassermann should be routine in every case.

The roentgenographic studies must include not only X-ray films of the involved bone in all aspects, but also of the corresponding bone for comparison, and X-ray

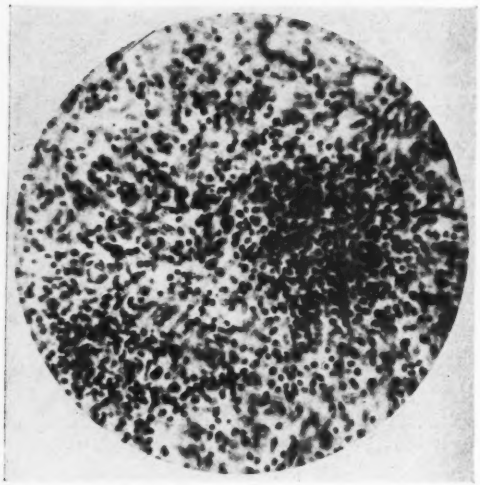

Fig. 16. Lymphoid-cell granulation tissue from bone shown in Figure 8.

films of the chest and pelvis for the demonstration of any possible metastasis or evidence of Paget's disease. In those instances in which metastasis is demonstrated in the X-ray examination or Paget's disease is suspected, there should be an X-ray examination of the skull in the lateral view. Routine dental films of all the teeth are indicated in order to eliminate this frequent cause of focal infection.

TREATMENT OF BONE LESIONS

First, we must consider the group which in the X-ray examination resembles sarcoma. We mentioned above that about 33 per cent fall into this group. It seems wiser here to try the effect of radiation first to demonstrate the presence or absence of a radiosensitive tumor, and at the same time to give an opportunity for about two weeks' observation. In a number of instances, during the course of radiation therapy, there has been pus formation or discharge of sequestrum, thereby establishing the diagnosis of a benign lesion.

In nine, or about 33 per cent, of the cases in which the X-ray findings were suspicious of sarcoma, biopsy, partial excision, or resection was done to establish the diagnosis, in a number of instances among the earlier cases without preliminary radiation. It seems that we are justified in making the statement, "when the X-rays suggest sarcoma, and when the tumor is radioresistant, and when the foci of infection are eliminated, we are justified in exploratory operation, provided the tumor—if malignant—is operable." In some instances, even though the Wassermann may be negative, it seems wise to give a provocative injection of arsphenamine with another Wassermann reaction.

There has been only one amputation in this series and that was in the case of a patient with Paget's disease, the lesion of the tibia showing a great deal of bone destruction. In one case in which the X-ray findings suggested sclerosing sarcoma (Fig. 7), mentioned above—a lesion of the upper third of the shaft of the femur—there was a biopsy in another clinic. The sections were diagnosed sarcoma. The patient refused amputation and was well eight years later when last heard from in 1922. In another instance a young man aged eighteen had pain for two weeks following a trauma two weeks previously. There was a lesion in the upper third of the femur, in the X-ray examination looking like sarcoma. As we have never cured a case of sarcoma of the upper third of the femur by amputation, and, because of the location of this lesion, the patient was given X-ray treatment. The sequestrum came away. He has now been well for six years. Five years ago we saw a young man, nineteen years of age, with a single lesion of the lower third of the femur (Fig. 6). There was no history of trauma and the Wassermann was negative. The X-ray examination showed sclerosis combined with ossification. At exploration the diagnosis of non-suppurative osteomyelitis was made from the frozen section, and, other than biopsy, nothing further was done. The patient has now been well for five

years. The results are now up to date. We have heard from the majority of these patients, and there has been no death from sarcoma.

MICROSCOPIC PATHOLOGY

Histologically, the picture varies from the remains of necrotic bone, with granulation tissue in which plasma cells predominate (Fig. 12), or compact bone with enlarged haversian canals, like that seen in Paget's, and fibrous stroma such as is seen in osteitis fibrosa, with many small capillaries sometimes showing perivascular inflammation easily differentiated from sarcoma (Fig. 13), to bone in which the haversian canals may be almost completely absent, with granulation tissue in between the bony lamellæ of the round- and spindle-cell type suggesting sarcoma (Fig. 7). In the syphilitic lesion the granulation tissue is of the lymphoid-cell type, and may suggest Ewing's tumor (Fig. 16).

BONE METASTASES

A STUDY OF 334 CASES

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ILLUSTRATIONS BY HERMAN SCHAPIRO

IN the following study an attempt will be made to correlate the various clinical features of the different metastatic lesions localized in the bones, together with the pathologic process involved; and to clarify the rather obscure results which have hitherto obtained with regard to the treatment of bone metastases (see Chart I and Table I).

For purposes of analysis it has been found convenient to group the 334 cases of osseous metastases according to the primary tumor from which the dissemination occurred. The result of this analysis has brought forth many interesting and novel features in the natural history and clinical course of the various secondary bone deposits.

Breast.—One hundred carcinomas of the breast were studied with secondary bone involvement. The majority of the primary lesions microscopically were found to be of the scirrhous type (58 cases); with a few instances of adenocarcinoma (six cases); medullary carcinoma (four cases); comedocarcinoma (three cases), and colloid carcinoma (two cases). In one patient the primary lesion was found to be fibrosarcoma.

The bones most frequently involved were found to be, in the order of their incidence: the spine, pelvis, femur, skull, ribs, and humerus, while metastases in the forearm and the lower leg were of infrequent occurrence. There was no definite relation found between the primary lesion and the homologous bony structure. In 16 cases in which there were complete data, eight cases showed a primary lesion with contra-lateral bone metastases, while an equal number of patients revealed ipso-lateral osseous lesions.

TABLE I.—METASTATIC BONE LESIONS

Incidence of Cases—Pathologic Fracture: Five-year Cures

Primary malignancy	Number cases	Osseous metastases		Pathologic fracture		Patients living over five years	
		No. cases	Per cent	Number cases	Per cent	Number cases	Per cent
Breast carcinoma	1914	100	5.2	15	15	1	1
Prostatic carcinoma	1040	134	12.8	3	0.2	0	0
Stomach carcinoma	537	7	1.3	1	14.3	0	0
Colon and rectal carcinoma	497	3	0.06	1	33.3	0	0
Melanoma	169	3	1.77	1	33.3	1	33.3
Uterine carcinoma	86	5	5.6	0	0	0	0
Hypernephroma	63	22	34.9	10	45.4	1	4.5
Ovarian carcinoma	60	1	1.6	0	0	0	0
Testicular sarcoma	42	1	2.4	0	0	0	0
Lung carcinoma	24	4	16.6	1	25	0	0
Ovarian sarcoma	15	1	6.6	0	0	0	0
Thyroid malignancy	15	6	4	2	33.3	0	0
Testicular carcinoma	13	1	7.7	0	0	0	0
Undetermined malignancy	....	37	....	15	40.5	2	5.4
Nasopharyngeal carcinoma	....	1	....	0	0	0	0
Squamous-cell carcinoma	....	2	....	0	0	1	0
Soft-part sarcoma	....	2	....	0	0	0	0
Bladder carcinoma	....	1	....	0	0	0	0
Esophageal carcinoma	....	1	....	0	0	0	0
Ileac sarcoma	....	1	....	0	0	0	0
Liver carcinoma	....	1	....	0	0	0	0

Many cases having multiple lesions on both sides of the body were valueless in determining this relation of primary tumor to metastases.

Clinically, pain of a severe rheumatic character was an important feature. When the metastatic foci were located about the spine, girdle pains and many other neurological manifestations appeared. Occasionally, pain preceded roentgenologic evidence of bone metastases for from three to eighteen months. The majority of the cases eventually showed a secondary type of anemia, with its complications, as the disease progressed. An occasional case report in the literature (1, 2) was found in which a pseudo-pernicious type of anemia was present, with a color index of over one, a slight leukocytosis, nucleated red blood cells, myelocytes, and myeloblasts. The ordinary anemia of cancer, according to Piney (3), is not dependent upon the presence of carcinomatous deposits in the marrow, but upon intrinsic changes in this tissue. The terminal phase of the disease was a progressive emaciation, usually with much pain, and when the lungs were involved (19 cases) respiratory embarrassment, with spitting of blood and paroxysms of coughing, were added features of discomfort.

Pathologic fracture occurred in 15 instances, 13 being in the femur, one in the ilium, and one case was recorded with multiple fractures of the ribs.

As seen by the X-ray, metastatic bone lesions from breast carcinoma were found to be most often multiple (Figs. 1-*A* and 1-*B*, Path. No. 37,870), presenting themselves as a single lesion (Fig. 2, Path. No. 23,091) in only one-fourth of the cases. The majority of the solitary foci were in the vertebræ or femur. Two types of metastatic lesions were noted in the X-ray films: The more common one was an osteolytic or bone-destructive lesion, while the other was a sclerosing or bone-forming process, the latter occurring in outspoken fashion only twice in this series of breast cancers, together with an occasional case reported in the literature. In the long bones,

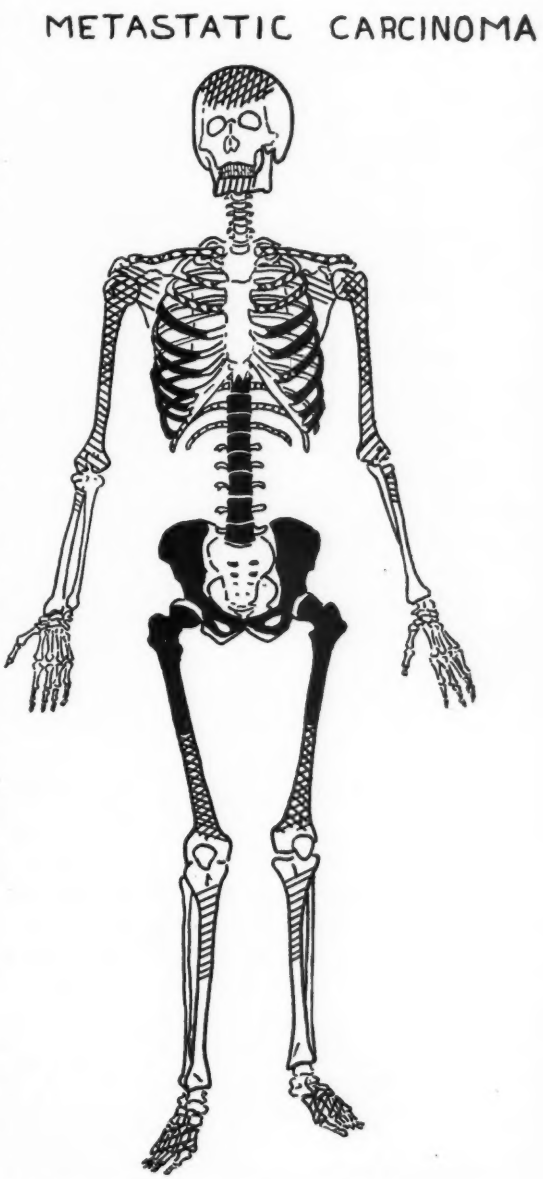
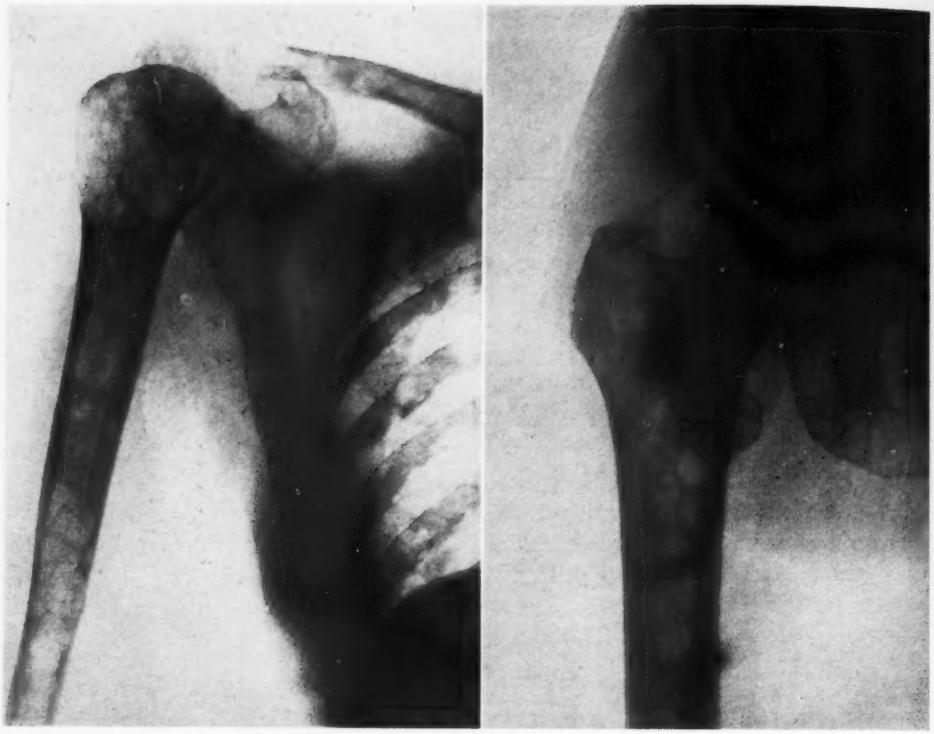


Chart I. Incidence of metastatic lesions of epithelial and connective tissue origin according to skeletal location. The solid black areas indicate the most frequent sites; the checked areas, the common sites; the diagonal lines, the occasional sites, and the white areas, rare sites.



Figs. 1-*A* and 1-*B*. Illustrating multiple foci in the skeleton, found to be predominant in mammary carcinoma. (1-*A*) Roentgenogram of the shoulder girdle showing multiple involvement of the scapula, humerus, clavicle, and ribs. Note the punched-out areas, with little or no bone formation. (1-*B*) Involvement of the upper shaft and head of the femur and adjacent pelvis. Path. No. 37,870.

the metastatic deposit was often found well above the average entrance of the nutrient artery in the case of the femur, and above or below it, in the case of the humerus. Mottling, representing an increase in bone density, was often found within the areas of destruction, together with thickening of the cortex above or below the site of metastasis (Fig. 3, Path. No. 35,420), and microscopically this proved to be an attempt at bone repair or fibro-ostosis (6). Bloodgood (7) has pointed out that evidence of such new bone formation may be used as a point in differential diagnosis in multiple tumors of the bone. When this new bone formation occurs as mottling within an area of bone destruction, it favors the presence of a metastatic process as opposed to the more definitely punched-out areas of bone destruction seen in multiple myeloma and other similar lesions of the bone. The pelvis, vertebræ, skull, ribs, scapulæ, clavicles, and sternum showed the same typical medullary involvement as the femur and humerus. The lack of distortion, or bending, of the bones was evidenced, due partly to the advanced stage of the disease, to X-ray therapy, which is not infrequently resorted to, and also to the brittleness of the bones, a consequence of age, making fracture, rather than bending, the rule.

An analysis of the gross and microscopic pathologic changes aided materially in the interpretation of the roentgen observations and of the modes of metastasis. The femur

Fig. 2. Metastatic involvement of the greater trochanter and neck of the femur, illustrating metastatic carcinoma as a single lesion in breast cancer. Path. No. 23,091.

Fig. 3. Roentgenogram showing metastases in the upper end of the femur, with mottling representing increased bone density within the areas of destruction. There is also thickening of the cortex below the site of metastasis. Path. No. 35,420.

and the humerus offered the most valuable information in the study of the gross material. It was brought out that metastases occurred both *via* the vascular route and by direct extension from other bones through the lymphatics. The humerus in most instances was found to be involved principally in the medullary and cortical areas in the shaft area, with subsequent invasion of the head. The femur often showed metastases in the head about the fovea capitis (Figs. 4-*A* and 4-*B*, Path. No. 40,002) and in the region of the greater trochanter, extending down into the shaft. The microscopic examination of sections taken from various points in these bones revealed destruction of the spongy and the cortical bone by the direct contact of the tumor cells with the bone (Fig. 5, Path. No. 40,002), and, to a lesser degree, by the activity of the osteoclasts destroying dead bone. Abundant evidence was found microscopically in proof of a natural tendency of bone to react by direct transition of fibroblasts to osteoblasts to osteoid tissue, in an effort to protect itself from further invasion and to rebuild that part already destroyed (Fig. 6, Path. No. 12,761). X-ray therapy in many instances caused a similar reaction when employed to a sufficient degree. The variation in the location of metastatic foci of the affected bones is to be explained in a subsequent paper as being the result of either a lymphatic permeation or a vascular mode of metastasis.

The treatment of the osseous lesions was considered for purposes of analysis on three types of patients: first, those who had a radical amputation of the breast; second, those who had only simple breast amputation or local excision, and third, those on whom no operation was performed, and who re-

Fig. 4-*A*. The upper end of the femur, the seat of metastasis from breast carcinoma. Note the tumor invasion about the fovea capitis and in the region of the greater trochanter. The neck has collapsed, with approximation of the head and the shaft. Path. No. 40,002.

ceived only various forms of palliative treatment.

In Group 1 there were 74 patients showing subsequent metastasis to bone. The average interval between the appearance of the primary tumor and the metastasis to bone was 32.5 months, and the time between radical removal of the breast and metastases averaged thirty months, with a few exceptions who developed bone lesions at intervals as late as from nine to twenty years. The malignancy in the patients of Group 1 was principally of the scirrhous type. The microscopic examination in 52 of the cases showed scirrhous carcinoma; medullary carcinoma (four); comedocarcinoma (three); adenocarcinoma (three); colloid carcinoma (one), with eleven unclassified.

In Group 2, 18 cases were found with an average interval of 29.1 months between the appearance of the primary tumor and the first evidence of metastases, while the interval between the breast operation and osseous involvement was 16.7 months. The types of microscopic pathology in the various primary breast tumors were, in the order of their frequency, unclassified (seven); scirrhus (six); adenocarcinoma (three); colloid carcinoma (one), and fibrosarcoma (one).

Group 3, or the inoperable group, contained eight cases. The interval between the appearance of the primary tumor and the metastases ranged between one and twenty-four months.

Treatment as given in this clinic is based upon the clinical experience of Dr. J. C. Bloodgood and Dr. Max Kahn. The X-ray treatment consists of 12 thirty-minute exposures, using 200 kilovolts, and five milliamperes, filtered through a filter combined of 0.75 millimeter copper and 1 millimeter aluminum, with a 25 cm. diaphragm opening and a 50 cm. focal distance.

A total of ninety minutes is given over each portal of entry in doses of thirty minutes each on consecutive days, four portals of entry being used. If further treatment is indicated, the above procedure is repeated after a free interval of three months or more, depending upon the condition of the patient.

In Group 1, two cases have survived the metastases for 71 and 48 months, respectively. After receiving irradiation by the X-ray the average duration of life was 18 months, as compared with 11.5 months for those who received no X-ray therapy.

In Group 2, the average duration of life of those patients with metastases who received X-ray therapy was 16.2 months as compared with 12.8 months for those who did not receive roentgen therapy.

In Group 3, the patients irradiated by the X-ray lived 10 months, while those without X-ray therapy lived 7.8 months.

Resection of the affected part apparently

had no effect on the duration of life, but did relieve pain, while roentgen therapy gave relief from the excruciating pain experienced in the diseased bone and in some instances definitely prolonged life. Many such instances of relief from pain by X-ray therapy have been reported (8, 9, 10).

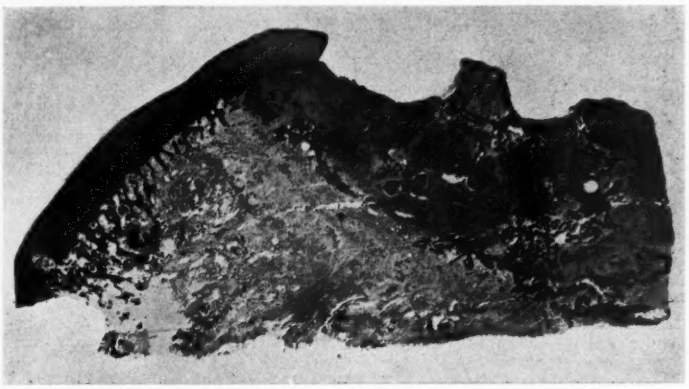


Fig. 4-*B*. A low-power photomicrograph of a section taken from the region of the fovea capitis, depicted in Figure 4-*A*. The tumor invasion can be seen below the site of the lesion. The joint cartilage is intact on either side of the tendinous attachment. Path. No. 40,002.

Hypernephroma.—Bone metastases were found in 22 cases of hypernephroma. The bones usually affected, in the order of their frequency, were: humerus, spine, femur, pelvis, ribs, bones of the feet, skull, sternum. The age incidence varied from 21 to 81 years. The clinical course was typical of metastatic bone lesions. A unique feature (11) was sometimes demonstrated on examination by the pulsatile character of the tumefactions. Pathologic fracture occurred in ten patients (45.4 per cent); six times in the femur, three times in the humerus, and in one instance multiple rib fractures were found. The bone lesions appeared in the X-ray films either as single or multiple foci, located in one or more bones. Single deposits were found in a long bone in the majority of instances (59 per cent).

Many of the lesions were found at sites of nutrient vessels (Fig. 7, Path. No. 29,461), while others involved the heads of the humerus and femur, together with the pelvis, suggesting strongly both a lymphogenous and hematogenous mode of metastases, especially the last-mentioned, where no intervening structures were found to be involved at autopsy. There was very little tendency on the part of the bone to react to the tumor by fibro-ostosis. The gross and microscopic pictures were of primary medullary involvement by the invading tumor, with osseous destruction and practically no healing reaction (Fig. 8, Path. No. 42,906).

In two of the cases with complete records, X-ray therapy was used in one instance, and in the other roentgen therapy with Coley's serum and amputation. Though pain was relieved, the disease proved fatal in both cases within two years.

Metastases of bone as seen in the various forms of primary malignancy in the male and female genital tract were studied in groups according to the primary organ involved.

Prostate.—In carcinoma of the prostate, 134 instances of metastases to bone were found among 1,040 cases affected by cancer. It must be pointed out, however, that only

Fig. 5. Microscopic picture of the tumor in the upper end of the femur shown in Figure 4-*A*. Note the destruction of the bone by direct contact of the tumor cells, the tumor being composed of epithelial cells arranged in nests, in places surrounded by fibrous tissue. Path. No. 40,002.

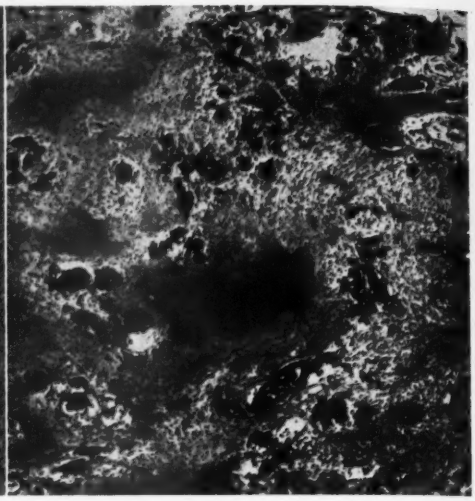


Fig. 6. A photomicrograph illustrating the natural tendency on the part of bone to react by direct transition of fibroblasts to osteoblasts to osteoid tissue, in order to protect itself from tumor invasion and to rebuild that part already destroyed. Note the sclerosis and bone formation crowding the tumor cells into strands and islands. Path. No. 12,761.

about 50 per cent of the total number of cases had been examined by the X-ray and in only 25 per cent of this number were metastases found.

The bones most frequently involved were the pelvis and vertebræ, more rarely the femurs, and in two instances the lower end of the tibia and the skull were invaded. The patients clinically suffered varying degrees of pain in the region of the pelvis—stiffness of the hip joints and sciatic discomfort. Many cases showed symptoms of urinary obstruction, with a subsequent progressive emaciation and secondary anemia. The age incidence was that of middle and late life (46 to 75 years).

As depicted in the X-ray film, all the metastatic lesions in the bones were predominantly of an osteoplastic nature (Fig. 9, Path. No. 42,182), a characteristic of prostatic carcinoma, in which there is marked bone formation with some destruction. Bumpus (12), in a study of 362 cases at the Mayo Clinic, found osteoclastic changes predominating in a few instances, but the majority of the bone lesions showed an osteoplastic reaction.

Upon gross examination of the material at hand, the metastatic nodules appeared as white or grayish nodules, surrounded and often permeated by a healing bone reaction. This response to tumor invasion was found to be quite the reverse of that usually seen in other metastatic lesions, except where osteoclastic lesions had been treated by X-ray therapy. This bone reaction to prostatic carcinoma suggested strongly the hypothesis that the invasive powers of the secondary tumor deposits were of such moderate character that bone proliferation kept pace with the tumor invasion. Roentgen therapy offered relief from pain but was not effective in eradicating the lesion or in greatly prolonging life. Amputation of a leg was done in two instances for relief of pain.

Testicle.—Malignancy of the testicle, with metastases to bone, was of rare occurrence—

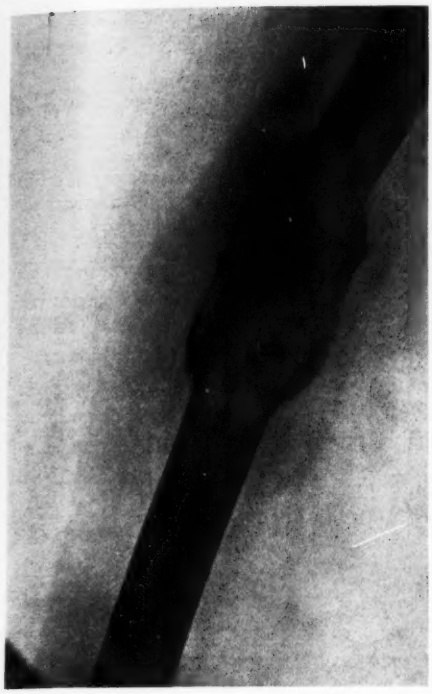


Fig. 7. Roentgenogram of the shaft of the humerus, the seat of metastatic hypernephroma. The destroyed bone is to be seen at the site of the nutrient vessels and at the attachment of the deltoid musicle. Path. No. 29,461.

only two patients in this group. One was a case with carcinoma of the testicle; the other, a sarcoma of the testicle. A review of the clinical course revealed progressive emaciation, with various neurological phenomena. In one case a lump appeared in the abdomen, attached to the retroperitoneal region, following removal of the testis. The ages of the men were, respectively, 40 and 56 years.

The X-ray film showed a destructive type of lesion, with no osteoplastic reaction. Roentgen therapy proved beneficial in the carcinomatous bone metastases by relieving pain, but little good was derived from irradiating the testicular sarcoma.

Bladder.—One example of carcinoma of the bladder, with metastases to bone, was

Fig. 8. Photomicrograph of tissue removed from a bone, the seat of metastatic hypernephroma. Note the clear foam-like cytoplasm in many of the cells. Path. No. 42,906.

recorded, with secondary deposits in the bones of the foot. Subsequently the lesion in the bladder (14) was found, following a severe attack of hematuria. No ultimate result could be arrived at in this case.

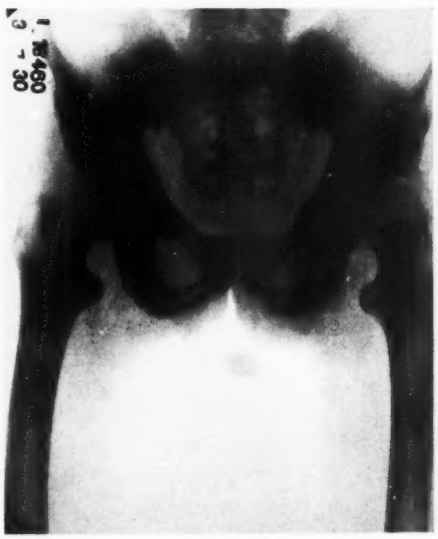


Fig. 9. Roentgenogram depicting multiple involvement of the pelvis and femora by metastatic carcinoma arising in the prostate. Such metastases are predominantly osteoplastic in nature. Path. No. 42,182.

Fig. 10. A roentgenogram of the upper end of the humerus showing involvement of the upper end of the shaft near the epiphysis, apparently beginning as a central lesion, expanding and destroying the cortex. Path. No. 26,823.

Fig. 11. Roentgenogram showing diffuse cystic destruction in the lower shaft of a femur from carcinoma of the stomach, metastasizing to the bone. Path. No. 39,012.

Uterus.—Carcinoma of the uterus metastasized to bone in five instances. Two of the primary tumors were in the cervix, while three were found in the body of the uterus. The age incidence in this group extended from 35 to 60 years.

Clinically, varying degrees of pain, with disturbance of function in the affected extremities, were common symptoms. The course of the advancing disease was dominated by secondary invasion of the primary tumor to surrounding organs. Apparently due to the fact that uterine carcinoma as a whole invades lymph nodes relatively late, there is a striking tendency on the part of the neoplasm to remain localized to the uterus or to its immediate vicinity until late in the disease, in contradistinction to cervical carcinoma, which invades the parametrium early. The roentgenogram of the osseous metastases revealed areas of bone destruction, four times in the pelvis, twice in the femur, once each in the humerus, skull, and metacarpal bones. There was no evidence of new bone formation and no periosteal reaction. The roentgen ray and radium proved particularly unsatisfactory in this group of cases.

Ovary.—Two instances of ovarian malignancy, with metastases to bone, were found among 69 such cases in this laboratory. In one instance the patient (age 47) was found

to have carcinoma, and in the other, sarcoma of the ovary (age 14). The bones affected in the first case were the third metatarsal, and in the second the skull, femur, and pelvis.

Clinically, pain in the affected bone was the first symptom of the disease in one case, while manifestations in the region of the primary tumor, namely, pain over the lower abdomen, tumor, and ascites, were the first symptoms in the second case. X-ray therapy gave some relief from pain, but death intervened twenty months after the onset of symptoms.

Thyroid.—In reports which deal with a large series of cases of thyroid malignancy, metastasis to bone is of relatively frequent occurrence, and Ewing (13) is of the opin-

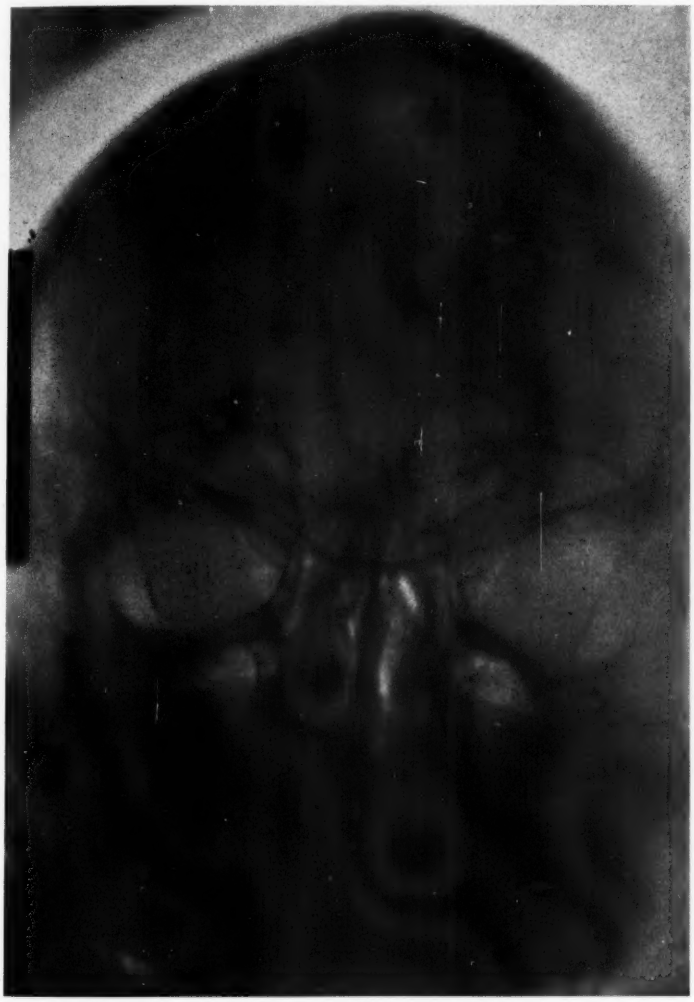


Fig. 12-*A*. Roentgenogram of the skull showing diffuse mottling in the frontal area, representing bone destruction by metastatic carcinoma arising in the lung. Path. No. 14,500.

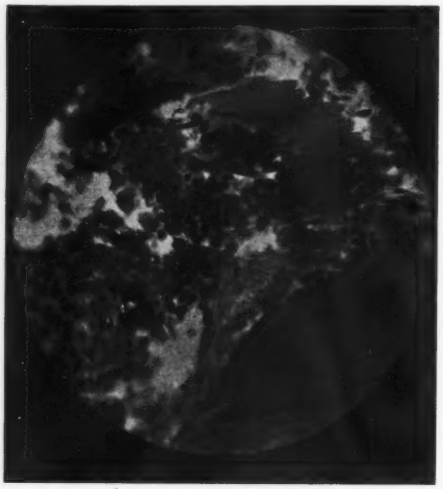


Fig. 12-*B*. Photomicrograph of tissue represented in 12-*A*, showing bone destruction by direct contact of tumor cells. Path. No. 14,500.

ion that the bones in thyroid malignancy are involved only less frequently than with mammary and prostatic cancer.

In our series of metastatic lesions only six cases of thyroid malignancy were found with metastasis to bone, with the peak of age incidence well above forty years. There were too few cases to allow one to draw any conclusions upon the incidence of bone involvement, but Ewing (13) gives the following order of frequency in the bones affected: skull, sternum, spine, ribs, humerus, femur, and pelvis. The metastases appeared near the epiphyses, either as central or subperiosteal lesions (Fig. 10, Path. No. 26,823). The clinical course was usually one of progressive emaciation, with symptoms referable to those bones which were the seat of metastases. Pressure symptoms in the neck region caused pulmonary embarrassment. In spite of X-ray therapy in one instance and Coley's serum, radium therapy, subsequent amputation, and X-ray therapy in another case, a fatal termination supervened, with only relief from pain in every case.

Gastro-intestinal tract.—Among lesions of the gastro-intestinal tract the stomach was found to be the most frequent site of a primary tumor which subsequently metastasized to bone. From a series of 537 patients who were found to have carcinoma of the stomach, only seven revealed bone metastases. The age of the patients affected ranged between 39 and 71 years. The bones involved were, in the order of their frequency: ribs (4 cases); pelvis and femur (3 cases); vertebræ (2 cases); sternum, skull, and scapula (one each). Most of the cases were examined only at autopsy, but in two cases in which X-ray examinations were made, either diffuse mottling and no distortion of the bone shell was present, or an expansion accompanied the central cystic lesion (Fig. 11, Path. No. 39,012).

The clinical course was usually one of emaciation, pain in the affected parts, and often neurological manifestations. An interesting feature of the blood was noted in one case, with enlargement of the lymph nodes. The white blood cell count was 10,600, with polymorphonuclear cells 30 per cent, eosinophiles 6 per cent, basophiles 2 per cent, myelocytes 26 per cent, myeloblasts 1 per cent, large lymphocytes 16 per cent, and small lymphocytes 11 per cent. The patient also showed tertian malarial parasites at examination.

Piney (3) and others have reported a pseudo-pernicious type of anemia in cases of carcinoma of the stomach, and, as was pointed out previously in this paper, breast carcinoma may show a similar blood picture.

Single examples of bone invasion from malignancies of the esophagus, cecum, sigmoid, rectum, ileum, and liver are recorded, with many of the features exemplified by metastatic lesions from stomach carcinoma. Only one patient in the series was treated by X-ray therapy, with some relief from pain but apparently without prolonging his life.

Lung.—Bone involvement was found to be present in four cases of carcinoma of the

lung. A wide variety of bones were involved, including the lumbar spine, pelvis, ribs, and skull. The clinical course of the disease revealed nothing unusual save that reported in other metastatic lesions. The X-ray film showed bone destruction with slight new bone formation, often within the area of destruction (Figs. 12-*A* and 12-*B*, Path. No. 14,500). Hirsch and Ryerson (14) report four cases in which the early diagnosis simulated "endothelioma of bone," and urge complete autopsies to rule out metastases from primary lung tumors.

Melanoma.—Melanocarcinoma is not of rare occurrence but few examples are cited as metastasizing to bone, only three such instances being recorded in this laboratory. The location in the long bones appeared about the site of nutrient vessels (Fig. 13, Path. No. 10,764). The clinical features of this type of bone metastasis were pain extending over a period of a year or more, occasionally pathologic fracture, and ultimately the symptoms of generalized dissemination of cancer. However, in this group of cases there is a patient who has been living for seven years and six months, following amputation of the left arm.

Interesting isolated examples of soft-part sarcoma (two cases); epithelioma (two cases), and adenoid cystic basal-cell carcinoma of the nasopharynx (one case) are recorded. They have followed the usual clinical course and termination of metastasis in general.

Fig. 13. Roentgenogram showing melanocarcinoma metastasizing to the upper third of the tibia. Note the expansion and cystic destruction of the shaft. Path. No. 10,764.

In many instances the clinician is unable to definitely diagnose the bone lesion after a thorough examination has been made, including X-ray plates, and when a biopsy is done little more can be said definitely concerning the etiology of the tumor.

There were 31 such cases under analysis in this laboratory and in none of them were we able to establish the location of the primary tumor. It is to be pointed out that the lesions were located in various parts of the skeleton and many of them were multiple. Not a few of the patients were relieved from pain for long periods of time by the administration of X-ray therapy, and in a few instances they lived from three to eight and one-half years following X-ray therapy or amputation of the affected part.

The question as to the mode of metastases immediately suggests itself when one reviews such a wide variety of lesions, and when the circumstances surrounding the

primary lesion and secondary metastases are analyzed, one cannot but be convinced of the dual method of dissemination—that is, by lymphatic permeation and embolism *via* the blood stream. This will be taken up in detail in a subsequent number of the *Archives of Surgery*.

BIBLIOGRAPHY

(1) Epstein, Julius: Blutbefunde bei metastatischer Carcinose des Knochenmarkes. Ztschr. f. klin. Med., 1896, XXX, 121.

(2) Houston, Thomas: The Conditions that Simulate Pernicious Anemia. British Med. Jour., Nov. 14, 1903, II, 1257.

(3) Piney, Alfred: Carcinoma of the Bone-marrow. British Jour. Surg., October, 1922, X, 235.

(4) Plank, T. H.: Bone Metastases from Carcinoma of Breast. Jour. Radiol., July, 1923, IV, 247.

(5) Ginsburg, S.: Osteoplastic Skeletal Metastases from Carcinoma of Breast: Report of Unusual Case. Arch. Surg., August, 1925, XI, 219.

(6) Geschickter, C. F., Copeland, M. M., and Bloodgood, J. C.: Osteitis Fibrosa and Giant-cell Tumor. Arch. Surg., August, 1929, XIX, 169.

(7) Bloodgood, Joseph C.: Bone Tumors, Benign and Malignant: A Brief Summary of the Salient Features, Based on a Study of Some Three Hundred and Seventy Cases. Am. Jour. Surg., September, 1920, XXXIV, 229.

(8) Ginsburg, S.: Pain in Cancer of the Breast: Its Clinical Significance, with Special Reference to Bone Metastases. Am. Jour. Med. Sci., April, 1926, CLXXI, 520.

(9) Levin, Isaac: The Prognostic and Therapeutic Significance of Skeletal Metastases in Carcinoma of the Breast. Ann. Surg., March, 1917, LXV, 326.

(10) Kelly, H. A., and Fricke, R. E.: Problems in Treatment of Carcinoma of the Breast. Surg., Gynec. and Obst., March, 1924, XXXVIII, 399.

(11) Gibson, A., and Bloodgood, J. C.: Metastatic Hypernephroma, with Special Reference to Bone Metastasis. Surg., Gynec. and Obst., October, 1923, XXXVII, 490.

(12) Bumpus, H. C.: Carcinoma of the Prostate: A Clinical Study. Surg., Gynec. and Obst., January, 1921, XXXII, 31.

(13) Ewing, James: Neoplastic Diseases: A Treatise on Tumors. W. B. Saunders Co., Philadelphia and London, 1928, Third Ed., p. 955.

(14) Hirsch, E. F., and Ryerson, E. W.: Metastases of Bone in Primary Carcinoma of the Lung: Review of So-called Endotheliomas of Bones. Arch. Surg., January, 1928, XVI, Pt. I, p. 1.

AN X-RAY AND CLINICAL STUDY OF THE BONES OF THE HANDS AND FEET

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From the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University

ONE out of every ten neoplasms occurring primarily in bone involves the small bones of either the hands or feet. Tumors thus located are met with sufficiently often to make it important for the roentgenologist or practitioner dealing with lesions of bone to familiarize himself with the peculiarities of this group of new-growths. In an attempt, therefore, to study tumors involving the small bones of the hands and feet it is necessary not only to study the X-ray characteristics, but also the clinical history and microscopic findings.

This study is based on 145 lesions of the small bones recorded in the Surgical Pathological Laboratory of Johns Hopkins Hospital from 1890 to 1930. A similar study was made in 1926 and reported in Radiology in April, 1927 (1).

EXOSTOSES

Of the forty cases in this group, the largest number, twenty-two (or about 50 per cent), involve the os calcis. On the X-ray film they are easily recognized. They are nearly always single but in a few exceptions they may be multiple. Such a lesion manifests itself as a bony spur of variable size, attached by a pedicle which may be broad. Exostoses usually have smooth borders which may be pointed, cauliflower-like, or rounded in appearance. They are sometimes cystic or they may be fractured and may be without symptoms. They are benign and the treatment consists chiefly of excision if they cause pain by pressure. If they produce no symptoms, they are best left alone. When once properly excised they seldom recur. The majority of the cases in this group occurred in males. The youngest patient was seven years of age and the oldest sixty-five years. The duration of the symptoms varied from two months to about fourteen years. The microscopic findings consisted chiefly of cancellous bone, with an overlying area of adult cartilage.

CHONDROMYXOMA

The chondromas numbered 45 cases, almost equally divided as to sex, 24 occurring in females and 21 in males. The youngest patient was six years of age and the oldest eighty years: 25 were between the ages of twenty and fifty years. In 30 cases the phalanges of the hand were involved; in 7, the metatarsals; in 6, the phalanges of the feet, and in 2, the tarsals. There were no cases involving either the carpals or the metacarpals. This is valuable from a diagnostic standpoint in differentiating these lesions from benign giant-cell tumor and bone cyst, which, when occupying a position

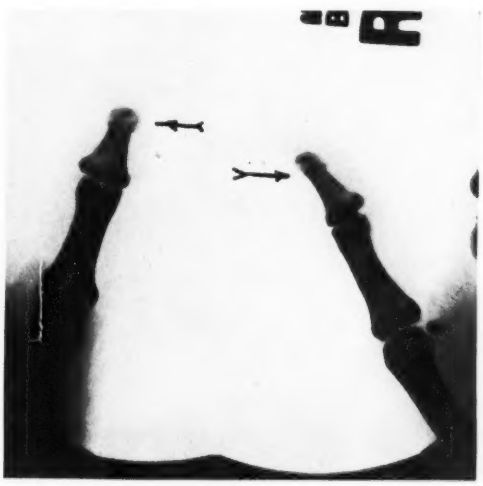

Fig. 1. Small round-cell sarcoma resembling Ewing's tumor, occurring as a subungual lesion.

in the hand, usually occur in the carpal or metacarpal bones. One of the lesions was multiple, involving the phalanx of the left thumb and the phalanx of the left index finger. The duration of the symptoms of the earliest case was seven days and of the oldest twenty-eight years. The commonest symptom in 24 cases was either tumor alone or tumor associated with trauma. Pathologic fracture was noted in two cases. The remaining cases gave some history of trauma.

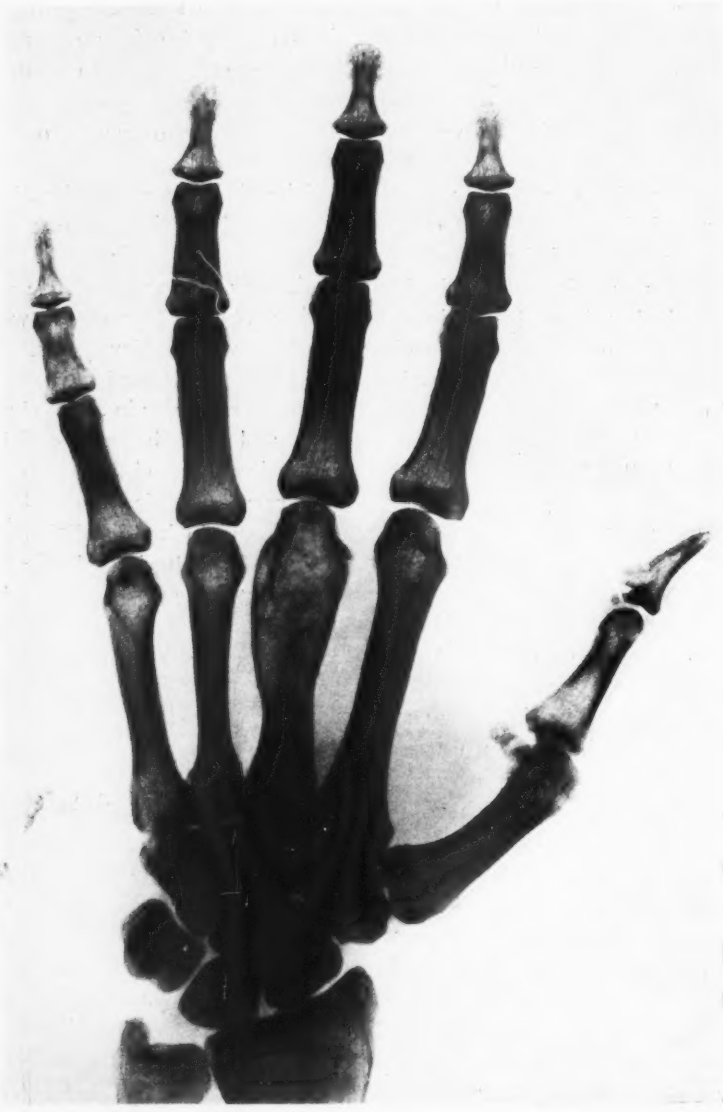

Fig. 2. Chondromyxoma in a metacarpal bone showing the central bone-destructive character and very fine trabeculation. Bone cysts or giant-cell tumors also occur in this region, but are more coarsely and definitely trabeculated. (Cf. Fig. 3.)

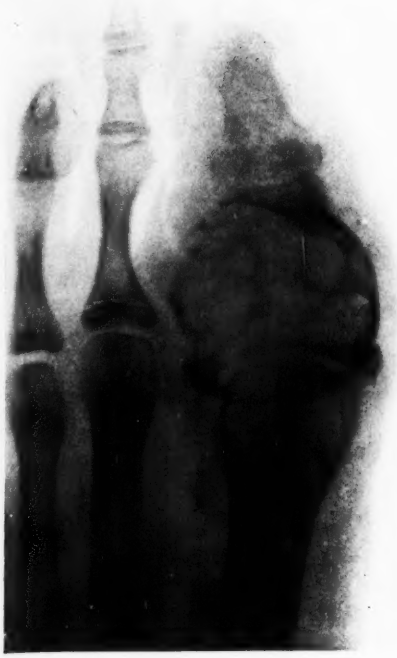

Fig. 3. Bone cyst occurring in the proximal phalanx of a big toe.

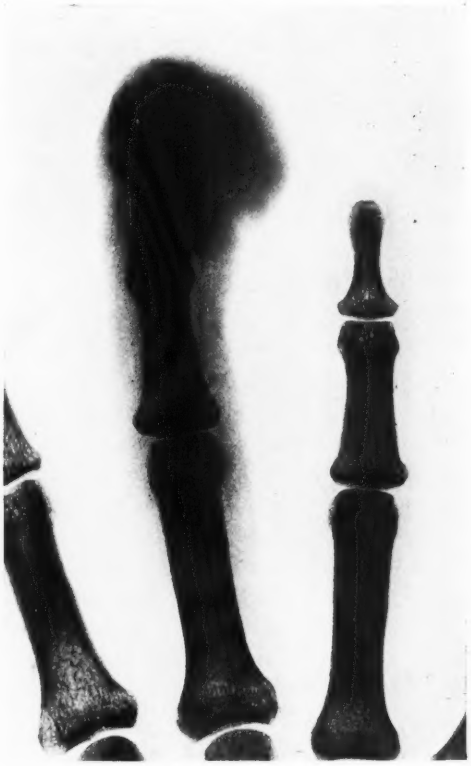

Fig. 4. Giant-cell tumor of a distal phalanx showing advanced bone destruction.

The X-ray findings are usually those of a single, central, expanded rarefied or translucent area, but occasionally there may be multiple areas. Seldom is there new bone formation. The treatment consists either of curettement, amputation, or excision. Two cases of our group were irradiated. The majority of patients upon whom operation was done were discharged well. Of the two cases irradiated, some improvement was noted in one, while the other was unimproved. The microscopic findings consisted chiefly of fetal cartilage and myxoma. In some, there was adult and calcifying cartilage. It was thought advisable to classify these tumors as chondromyxomas, since they frequently contain both cartilage and myxomatous tissue. In an earlier study we separated these tumors and divided them into chondromas and myxomas.

GIANT-CELL TUMORS

There were twelve cases of giant-cell tumor, the youngest patient being ten years of age and the oldest sixty years. Pain, trauma, and tumor were the commonest symptoms and varied in duration from six months to thirteen years. The X-ray findings revealed a bone shell, with expansion, usually without trabeculation. In these tumors the bone shell may be either intact or perforated. The treatment consisted of irradiation in one case; in the others, resort was had to either excision, curettement, resection, or amputation. The microscopic

findings consisted of a spindle-cell stroma containing many large multinucleated giant cells. Practically all patients were well five to ten years later.

CYSTS

There were nine cases of osteitis fibrosa, the youngest patient being four years of age and the oldest fifty-one. The chief symptoms were trauma and tumor, and the duration was from four months to five years. The X-ray revealed a small cyst, with some bone expansion and trabeculation. The differential diagnosis between giant-cell tumor and osteitis fibrosa is rather difficult, but usually the bone expansion is not quite so marked and the trabeculation is more evident in a cyst. The treatment consisted either of curettement, excision, resection, or amputation. Practically all patients were well from one to eight years.

XANTHOMA

There were twenty cases of xanthoma involving the tendons and joints of the small bones of the hands and feet. There is no characteristic X-ray picture of this condition. The microscopic findings are usually those of typical giant-cell areas in the tendons connected with the joints. Geschickter and Copeland have described this condition in detail (2).

SARCOMA

There were three cases of sarcoma, two of the feet and one of the hand. One case under observation by Dr. George H. Hess is of especial interest, and a brief abstract of the history of this case follows. The patient was a boy, fifteen years of age, who had injured his foot two months before the first examination (on September 8, 1927), while jumping. At the time of this examination there was a hard, non-painful, non-inflammatory tumor mass about the size of a walnut in the region of the base of the second metatarsal bone. This was removed and films and slides sent to Dr. Bloodgood, who reported sarcoma. The local pathologist diagnosed it as a small round-cell sarcoma. The patient had no recurrence at the site of operation at the time of admission into the hospital in July, 1928. His chief complaint at this time was weakness, shortness of breath, and a cough which had begun about five weeks previously. At this time the entire right chest was flat, with the heart sound displaced to the left. Aspiration of the chest showed a large quantity of sterile bloody fluid. The urine and blood counts were normal. The temperature ranged between 100° and 103°; pulse 120; respirations 36. X-ray films of the lungs made at this time showed metastatic sarcoma, there being circumscribed areas of density scattered throughout. The patient died about September 1, 1928.

CARCINOMA

There were six cases of carcinomatous metastases to the skeleton involving also bones of the hands or feet. The diagnosis in these cases was always easily made on the basis of the other lesions present in the bones of the trunk or of the extremities, for in no case was metastatic involvement of the small bones observed, unless a generalized skeletal metastasis was present.

CONCLUSION

This study emphasizes the rarity of malignant lesions in the small bones of the hands and feet. If the lesion is single in character and central and osteolytic in type, malignancy can practically be ruled out on the basis of the X-ray examination. Periosteal, osteogenic sarcoma occurring as a single lesion in the small bones of the extremities is rare. It is found in about 2 per

cent of the cases and is difficult to differentiate in the roentgenogram from the more frequent lesion of ossifying periostitis. The usual tumor encountered in the bones of the hands or feet contains cartilage and is either an exostosis or a chondromyxoma, both of which can be safely treated as benign. Most of the remaining tumors are of the giant-cell group, or the pathologically closely related lesions of osteitis fibrosa or xanthoma, which also are typically benign. When metastatic nodules occur in the small bones, their nature may be readily discerned by the presence of diffuse involvement of the remainder of the skeleton, which is always associated with their presence in the small bones.

REFERENCES

(1) KAHN, MAX, and COHN, L. CLARENCE: Diagnosis and Treatment of Bone Lesions of the Hand and Foot, with Special Reference to Bone Tumors. RADIOLOGY, April, 1927, VIII, 289.

(2) GESCHICKTER, CHARLES F., COPELAND, MURRAY M., and BLOODGOOD, JOSEPH C.: Osteitis Fibrosa and Giant-cell Tumor. Arch. Surg., August, 1929, XIX, 169.

CENTRAL TUMORS OF THE LOWER JAW

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IN the X-ray diagnosis of bone tumors it is as important to realize the limitations of the X-ray as it is to recognize those diagnostic characteristics which the film reveals. With the aid of the X-ray the central bone-expansive tumors of the lower jaw can be differentiated from periosteal lesions and osteomyelitis. But central bone-destructive tumors of the jaw include (1) the root or alveolar abscess, (2) its derivatives—the granuloma and root cyst, (3) the dentigerous cyst, (4) the adamantine epithelioma, (5) the giant-cell tumor, (6) the fibroma and fibrosarcoma, and (7) rarer lesions such as carcinoma arising from the gums, and myxoma. After recognizing a lesion as central, further identification is sometimes difficult. This problem of differential diagnosis is the topic of the following pages, based on a study of the jaw tumors in the Surgical Pathological Laboratory of the Johns Hopkins Hospital.

Fig. 1. Roentgenogram showing an area of bone absorption about a carious molar. An alveolar abscess. (Dr. Kahn's case.)

The root abscess.—The most frequent finding in a routine X-ray examination of the teeth is the presence of periapical areas of bone absorption about non-vital teeth whose apices may be more or less eroded (Figs. 1 and 2). This characteristic picture of a locally symptomless lesion is usually called a root or alveolar abscess. If, however, the tooth be extracted, no pus, but, rather, a granuloma or sometimes a root cyst will be found. The granuloma is the sequel of an acute apical peridontitis in which the intense inflammation has subsided, with the formation of a nodule of chronic granulation tissue. Strands of squamous epithelium, arising from the irritated epithelial rests remaining about the tooth root, are a frequent finding in microscopic sec-

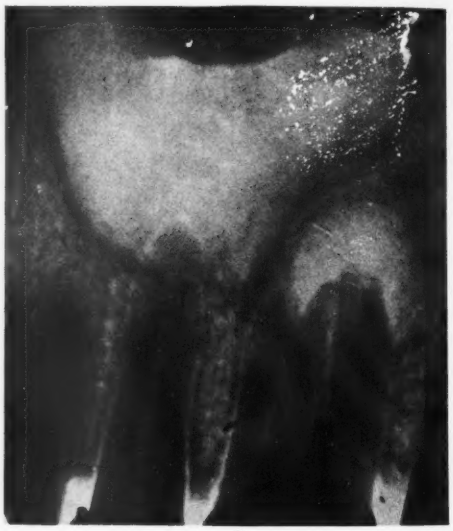

Fig. 2. Roentgenogram showing an area of bone absorption with a sclerosed wall about the first upper molar. This is a chronic abscess or granuloma. (Dr. Kahn's case.)

Fig. 3. Photomicrograph of a dental root cyst showing the epithelial lining. To one side lies the chronic granulation tissue found in granulomas. Path. No. 39 572.

Fig. 4. Roentgenogram of a central lesion one year after the bicuspids and molar had been extracted because they were loose. Sections showed squamous-cell carcinoma. Path. No. 29,600.

tions of such a granuloma. When cystic degeneration occurs in these epithelial sprouts a dental cyst lined by stratified squamous epithelium is the result (Fig. 3). The granuloma is of small size, while the root cyst may grow by continuous desquamation of epithelial cells and expand the jaw bone to such an extent that parchment crepitation may be elicited on pressure. The recognition of the so-called root abscess is most important, not only because root abscesses may give rise to osteomyelitis or act as foci of infection in various chronic conditions but because early malignancy must be excluded. The roentgenogram of a root abscess is quite characteristic. When, however, the film shows an atypical area more films should be taken for further study, and, upon extraction of the tooth, sections should be made from tissue adherent to the tooth or from the root socket. It should be unnecessary to note that teeth should not be extracted without first taking X-ray films. This laboratory contains many cases of tooth extraction in early malignancy performed with the hope of relieving local symptoms in which either no X-ray has been made or else it has been incorrectly diagnosed as a root abscess. In these early cases the X-ray, supplemented by the microscope, performs an invaluable service.

A case history (Path. No. 29,600) may illustrate the above point. The patient, a white male aged 50, was a heavy smoker and carried a few patches of leukoplakia in his mouth. He complained of looseness of a molar and two bicuspids, which were examined by the X-ray. The film was interpreted as an abscess, the teeth extracted, and no tissue was saved. A year later the patient sought relief for pain and swelling of the jaw. The X-ray film (Fig. 4) taken at this time was thought to be that of a root cyst. At operation, no cyst was found and tissue from the cavity, sent to this laboratory, was

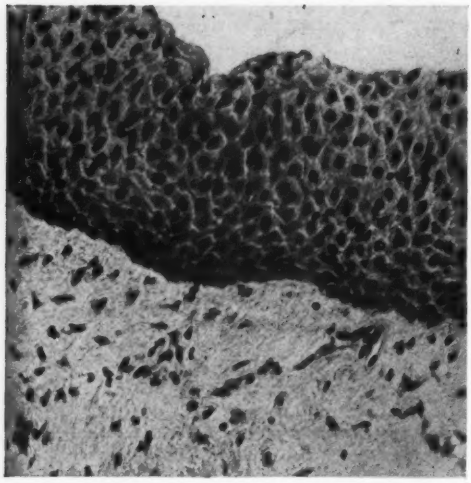

Fig. 5. Photomicrograph of the stratified squamous epithelial lining of the cyst shown in Figure 3. Note the desquamating epithelial cells. Path. No. 39,578.

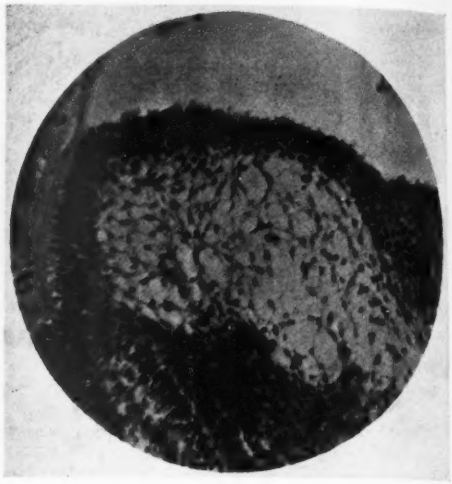

Fig. 6. High-power photomicrograph of a polycystic recurrent adamantinoma. The cystic degeneration in the stellate reticulum and the peripheral tall columnar cells are shown. Path. No. 17,524.

diagnosed as squamous-cell carcinoma. Cautery, resection of the jaw, and radium failed to save the patient. This is an example of the manner in which squamous-cell carcinoma of the gum following a leukoplakia may grow down along the side of the tooth and produce the local symptom of a loose tooth, finally invading the marrow cavity of the jaw.

When the X-ray film shows a central bone-destructive lesion of three or more centimeters in diameter so that neighboring tooth roots are involved, an X-ray diagnosis becomes difficult, as such a lesion may be a growing dental root cyst, a dentigerous cyst, a central fibroma or sarcoma, a giant-cell tumor, or even a squamous-cell carcinoma originating from the mucous membrane. The history is of importance. The common story of a painless, slow growing swelling situated near the angle of the jaw, in a patient in the third decade of life, enables one to exclude those tumors of rapid growth, but still does not establish the diagnosis. The findings on examination—the size, form, character on palpation, parchment crepitation, a chronic draining sinus with perhaps enlarged submental and submaxillary glands—all these are of no absolute diagnostic value. The various possible diagnoses of such a central lesion are discussed in their order of frequency as determined by our case histories.

The dental root cyst.—The dental root cyst, next to the granuloma, is the most frequent lesion. It arises from a granuloma in which epithelial strands have undergone a cystic degeneration. This cyst slowly increases in size by a desquamation of the stratified squamous epithelium lining the cyst wall (Fig. 5). The root cyst may arise at any age, and most frequently about the bicuspids and molars. It is a slow growing tumor, usually painless, distending the alveolar process in a half sphere about the root tip. The mucous membrane is normal. Depending upon the degree of bone distention, the swelling will be bony hard, upon further distention elastic, giving rise to parchment crepitation or even fluctuation. An elastic wall may become firm due to new bone formation. Occasionally the cyst will

expand along the jaw and marrow cavity and finally occupy the greater part of the jaw. A granuloma left behind in the jaw after a tooth extraction sometimes develops into a root cyst, offering thereby a lesion difficult to diagnose. When a cyst is found at operation the solid central tumors are excluded, but the lesion can be identified with certainty only by the microscope, which shows a cyst lining of stratified squamous epithelium. This lining should be stripped from the cyst wall. No further treatment is necessary.

Adamantine epithelioma.—The next most frequent lesion of our series is the adamantine epithelioma (38 cases). This tumor is a true neoplasm arising from the enamel organ, its favorite site being in the neighborhood of the molars, an area which is also a site of predilection for dentigerous cysts and giant-cell tumors. The age at which adamantinoma arises roughly corresponds to the time of second dentition, *i.e.*, between fifteen and twenty-five years. Because of its slow, painless growth the patient may not notice any swelling for a long time. In our series there are seven cases in which fifteen or more years had elapsed between the first recognition of the tumor and the patient's appeal for medical aid. Sometimes after a long slow growth a sudden increase in size of the tumor brings the patient to the physician.

Microscopically a characteristic picture is found: lying in a fibrous stroma are epithelial strands, morphologically similar to the early enamel organ, showing a peripheral layer of tall columnar cells with nuclei basally situated and an adjoining layer of transitional cells enclosing a stellate reticulum in which cystic degeneration is frequently found (Fig. 6). In the gross the tumor is solid, with small cystic areas, or else mono- or polycystic (Fig. 7). On section, the solid tumor presents white friable areas traversed by fibrous septæ enclosing cysts of varying size.

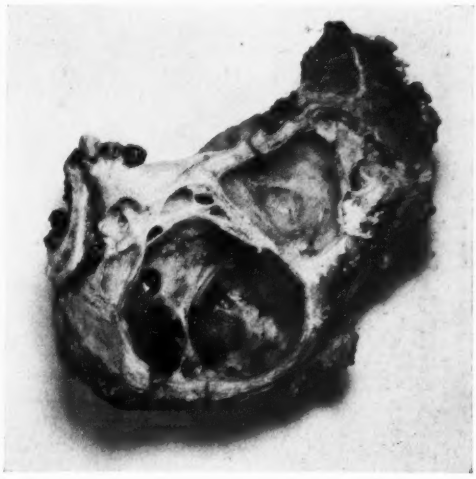

Fig. 7. A gross specimen from a polycystic adamantinoma showing two large cavities and numerous smaller cysts. Path. No. 31,404.

The X-ray film shows a central expansive lesion of clearly demarcated outlines (Fig. 8). All polycystic lesions are not, as is generally supposed, adamantine epitheliomas (Fig. 9): the trabeculation found in the giant-cell tumor and large root cyst may simulate this polycystic appearance. The solid or monocystic adamantinoma can not be differentiated from other central tumors by the X-ray.

The adamantine epitheliomas are characterized by their tendency to recur when incompletely removed—18 of our 38 cases are recurrent. Four patients have died of the tumor. When left alone, the tumors never metastasize but ultimately cause great destruction of the jaw by distention. The large number of recurrences in our series is evidence that simple curettage frequently fails to remove all of the tumor. Moreover, the inadequacy of even a complete resection of the jaw in several cases of repeated recurrences stresses the necessity of effective primary treatment. Bloodgood (1) reports the case of an adamantinoma at the angle of the lower jaw (Fig. 10) in which chemical cautery was used with success. The

Fig. 8. Roentgenogram of an adamantinoma arising in the anterior third of the jaw. The teeth had been pulled three years previously without any decrease in the swelling. Path. No. 36,356.

continuity of the jaw was preserved and the facial deformity is scarcely noticeable. The patient has now been well for nine years. The lesion was a single cyst. This same procedure was successful in two other cases of monocystic adamantinoma. In polycystic tumors it is impossible to reach with cautery all the recesses in which invasion may have occurred, and resection is indicated. When the polycystic lesion has expanded the jaw bone to a thin shell, the preservation of continuity by leaving a bridge of bone ought not to be attempted. As Lewis (2) has pointed out, recurrence almost invariably takes place in that bridge of bone.

There is no evidence to show that either the X-ray or radium is of benefit in the treatment of adamantine epithelioma.

Dentigerous cyst.—The dentigerous cyst, a cystic degeneration of the enamel organ, occurs much less frequently than the root cyst. Partsch (3), in a series of cases collected during a period of twenty years, found 394 dental root cysts and 13 dentigerous cysts, a ratio of 30 to 1. The dentigerous cyst arises early in the development of the tooth germ. That tooth corresponding to the abortive enamel organ fails to erupt, leaving a vacant space in the alveolus. As in the adamantinoma, the site of the molar teeth is the one of predilection. The growth is the same as that of the root cyst and adamantinoma, *i.e.*, slow and painless, gradually distending the jaw. The X-ray reveals the non-erupted tooth, varying in size from a bit of enamel to a fully developed crown lying within the cyst cavity (Fig. 11). A non-erupted tooth in a large cyst does not exclude a giant-cell tumor or adamantinoma (see Fig. 9). The pathology at operation, and frozen section if necessary, will establish a diagnosis. The cyst is lined with stratified squamous epithelium identical with that found in root cysts. The dentigerous cysts need not be cauterized. The cyst should be stripped of its epithelial lining.

Giant-cell tumor.—Next in frequency occurs the giant-cell tumor. Geschickter and Copeland (4) have shown the relation of the giant-cell tumor to cartilaginous bone and how in the lower jaw giant-cell tumors arise from remains of Meckel's cartilage, *i.e.*, at the symphysis and at the angle of the jaw. Of the fourteen giant-cell tumors in their series, nine were situated at the symphysis, three in the ascending ramus, and two were of undetermined origin. This tumor is of rapid growth—seven months is the average duration, although one patient carried the tumor for three years. The age incidence is greatest in the second decade; eleven patients were under twenty-three years of age, and only three over thirty. This is most curious, since giant-cell tumors of the long bones are found in patients over twenty-five years of age.

The X-ray film shows a central, clearly demarcated, bone-expansive lesion which, when large, reveals trabeculation (Fig. 12). Since most patients are young, non-erupted

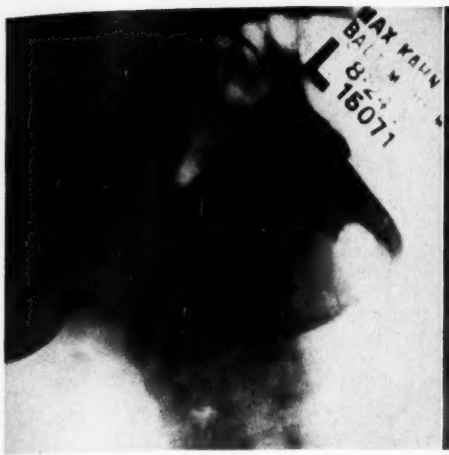

Fig. 9. Roentgenogram of a dental root cyst. Note the polycystic appearance of the lesion. The teeth had been extracted, with no relief of symptoms. Path. No. 40,810.

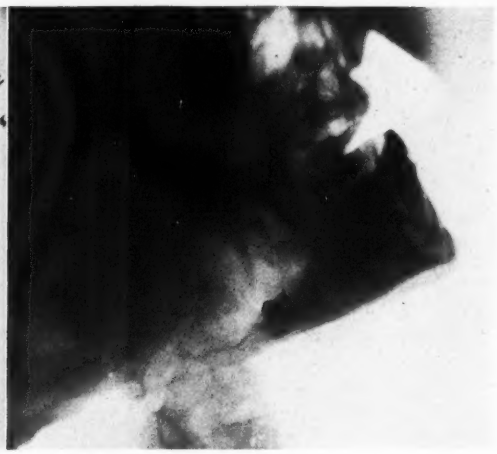

Fig. 10. Roentgenogram of an adamantinoma at the angle of the jaw expanding the ascending ramus to such thinness that the clasps cannot be seen in the film although they could be palpated. Note the molar tooth which the tumor has overridden. Path. No. 27,596.

teeth are a frequent finding. This often leads to an X-ray diagnosis of dentigerous cyst. While the X-ray appearance is not distinctive, the rapid growth of the tumor should suggest giant-cell tumor. The pathology at operation—a red, friable, hemorrhagic tissue — is further evidence of giant-cell tumor, but a frozen section should be made, since occasionally adamantine epithelium may resemble giant-cell tissue.

In the treatment of giant-cell tumor, Bloodgood (1) advises resection when complete removal of the bone involved does not interfere with function. Otherwise, thorough curettage followed by chemical cautery should be performed. The chemical cautery consists of phenol followed by alcohol and then by a 50 per cent solution of zinc chloride. Resection of the jaw is unnecessary and mutilating.[1]

Central fibromas.—Central fibromas are comparatively rare lesions; there are only six verified examples in this laboratory. The growth is slow and gradual, although sudden increase in size may occur. Usually there is no pain. The patients are young adults—twenty-five is the average age, fifteen and thirty-eight the extremes. The swelling is of a duration varying from one to fifteen years. One case showed bilateral

Fig. 11. Roentgenogram of a dentigerous cyst showing a tooth lying within a central cavity. (Dr. Kahn's case.)

[1]While X-ray therapy of giant-cell tumors of the long bones has its definite sphere of usefulness, in giant-cell tumors of the jaw, because of the difficulty in diagnosis, X-ray therapy has a limited scope.

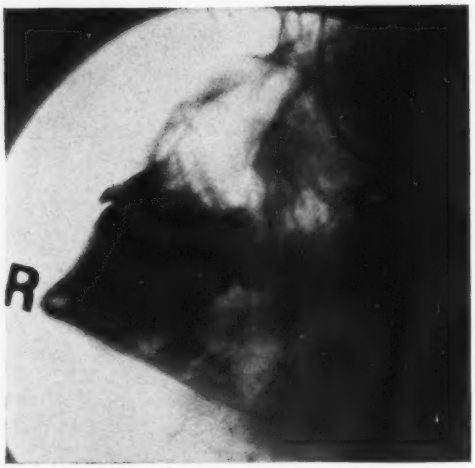

Fig. 12. Roentgenogram of a giant-cell tumor at the angle of the lower jaw. The patient's age is 12, hence the unerupted teeth. Path. No. 36,750.

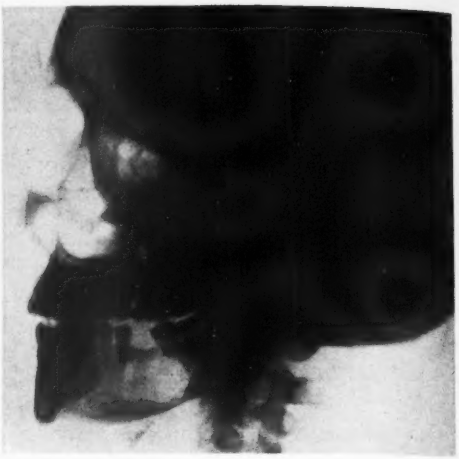

Fig. 13. Roentgenogram of a central fibroma of the lower jaw. This diagnosis was made only at operation by the aid of frozen sections. Path. No. 42,680.

swelling which had persisted for twelve years, since the age of three. Palpation reveals nothing of differential value.

The X-ray film shows a central expansive lesion of clear outlines, not characteristic (Fig. 13). In one case trabeculation was noted. The operator must be prepared to make the diagnosis from the gross appearance and frozen sections. Microscopically these central fibrous tumors vary from purely fibrous to fibrosarcomatous structures. In one central fibroma the recurrence was a spindle-cell sarcoma, and metastases, with death, followed the original curettage. This instance emphasizes the necessity of thermal and chemical cauterization of the cavity from which these tumors can be shelled.

Rare lesions.—New (5) reports bone cysts at the angle of the jaw, filled with a "cooked oatmeal-like" material, without an epithelial lining and of unknown etiology. They are quite benign. We have no examples of such cases. In multiple osteitis fibrosa cases of jaw involvement have been reported. There is one instance in our laboratory of a central myxoma which grew out of a tooth socket following extraction for pain. The X-ray films made before the extraction were negative. A section of the outgrowth showed myxoma. Radium packs were applied, followed by a curettage and cautery, with no recurrence to date (18 months). Multiple myeloma has not been observed in the lower jaw. We have one case of metastatic carcinoma involving the jaw. The rare odontoma, a solid tumor composed of varying proportions of dentin, enamel, and cementum, affecting the molars in the region of the submaxillary angle, can be recognized in the X-ray film as solid. The tumor is quite benign and can be shelled out of its capsule.

Osteomyelitis.—In old root cysts, dentigerous cysts and adamantinomas which have expanded the jaw bone to paper-thin size, a rupture of the cyst wall, with chronic discharge into the mouth, is not an infrequent occurrence. At times the resulting infection of the tumor gives rise to an acute osteomyelitis, complicating the original condition. In three cases of adamantine epithelioma, osteomyelitis was the clinical and X-ray diagnosis, but the findings at operation, verified

microscopically, established a correct diagnosis and procedure.

SUMMARY

Tumors of the lower jaw are shown by the X-ray to be either central or periosteal. Of the central tumors, the dental root abscess, granuloma, and small root cyst—as well as the small dentigerous cyst because of its contained tooth—can be identified with certainty. Atypical lesions should be studied microscopically to exclude early malignancy. Monocystic lesions larger than three centimeters cannot be diagnosed differentially by the X-ray. Only the findings at operation, verified by the frozen section, can establish the pathology. A polycystic appearance is produced by any of the central tumors, but most often by the adamantinoma and giant-cell tumor.

The dental root cyst and dentigerous cyst are treated by excision, with stripping of the epithelial lining from the cyst wall. Giant-cell tumor and the monocystic adamantinoma are attacked with chemical cautery. Polycystic adamantinomas should be resected. The bone cavity left by a central fibroma must be treated with chemical and thermal cautery.

BIBLIOGRAPHY

(1) Bloodgood, Joseph C.: Method of Operative Attack for Central Lesions of Lower Jaw. New York St. Jour. Med., March 21, 1924, XXIV, 379.

(2) Lewis, Dean D.: Multilocular Cysts of Jaws. Surg., Gynec. and Obst., January, 1910, X, 28.

(3) Partsch: Cited by Römer in Handb. d. spez. path. Anat. u. Hist. Henke and Lubarsch, Berlin, 1928, IV, Heft 2, 412.

(4) Geschickter, C. F., and Copeland, M. M.: Osteitis Fibrosa and Giant-cell Tumor. Arch. Surg., August, 1929, XIX, 169.

(5) New, G. B.: Roentgenologic Diagnosis of Pathologic Conditions of Jaw. Radiology, August, 1924, III, 165.

LESIONS OF THE UPPER HUMERUS

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TUMORS of bone occurring in the upper end of the humerus offer to surgeon and patient distinct advantages for early diagnosis and effective treatment. These advantages are derived from the ready palpability of a tumor in this location, its accessibility to surgery, and the possibility, in malignant disease, of combining radical procedure with a fair plastic and functional result, that is, resection with subsequent bone graft. Resection of the upper end of the humerus offers as much in the treatment of malignant tumors as does amputation.

The upper humerus is an occasional site for all common bone tumors and a favorite site for exostoses, bone cysts, and, among the malignancies, chondrosarcoma and metastatic carcinoma. The tumors arising from pre-cartilaginous and pre-osseous connective tissue or in connection with the growth of cartilage, both benign and malignant, predominate.

Primitive connective tissue, capable of forming both cartilage and bone, may give rise to benign and malignant tumors. Moreover, the benign tumors of such origin may undergo malignant change. Cartilage and bone formation characterize these tumors and bone destruction is prominent only in advanced malignant cases. The benign members of the group are exostosis and

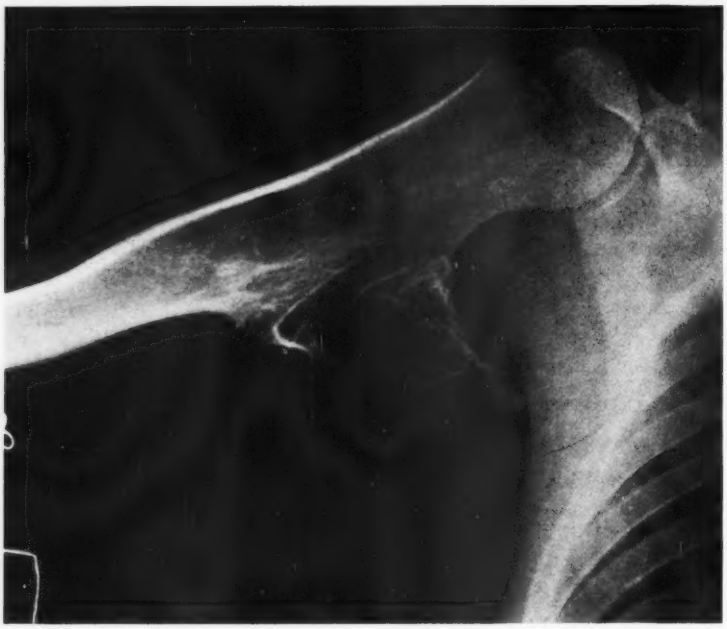


Fig. 1. Benign exostosis. An osteochondroma showing a broad base of normal bone, with a cartilaginous cap of exceptionally large proportions, the cap containing calcareous and bony trabeculæ. Path. No. 12,770.

Fig. 2-*A*. Chondrosarcoma (primary). Roentgenogram before operation. Note the fuzzy, infiltrating outer margin and the fine multilocular appearance within the tumor. The destruction of the cortex is apparent. Path. No. 40,690.

Fig. 2-*B*. Roentgenogram of same case shown in Figure 2-*A*, after operation. The upper third of the humerus has been resected. A recurrence has taken place two years after operation.

chondroma; the malignant, chondrosarcoma and the sclerosing type of osteogenic sarcoma. In the upper humerus, chondrosarcoma is by far the most important of these. This tumor, while occurring with slightly greater frequency in the upper tibia, constitutes 29 per cent of the malignant lesions of the upper humerus.

Exostosis is readily identified in the X-ray film by its base, or pedicle, of normal bone projecting through a gap in the periosteum and surmounted by a cartilaginous cap. This condition arises usually between the ages of ten and twenty-five and is most frequently found in the ends of the long bones at the site of a tendon attachment. It is common in the upper humerus. Occasionally, multiple exostoses occur as manifestations of an hereditary congenital bone disease which also produces bending of the bones and other skeletal deformities. These multiple congenital tumors should not be excised until the growth period is ended. Both the single and the multiple type may give rise to secondary chondrosarcoma.

Chondroma, or chondromyxoma, a benign tumor usually occurring in the small bones of the hands or feet, is rare in the long bones. Two cases of benign chondroma in the upper humerus and five cases of secondary chondrosarcoma arising in chondroma are recorded in this laboratory. In the X-ray film, this tumor is apt to appear as a finely multilocular, translucent shadow beneath the cortex. The common age incidence for benign chondroma is between twenty and thirty.

Chondrosarcoma may be a primary malignant tumor or, as has been stated, a malignant tumor secondary to a benign exostosis or chondroma. Of our cases, 28 per cent were primary and 72 per cent, secondary. The primary type most frequently appears between the ages of fourteen and twenty-one years; the secondary, after thirty-five. The onset of malignancy in secondary chondrosarcoma is marked by rapid increase in size and beginning pain. In the X-ray film,

Fig. 3-*A*. Chondrosarcoma (secondary to benign chondroma). Roentgenogram showing medullary destruction and pathologic fracture, which are almost wholly obscured by the tremendous soft-part shadow. Path. No. 42,888.

Fig. 3-*B*. Gross specimen of the same tumor shown in Figure 3-*A*. The invasion of the marrow cavity is apparent, and the multiloculated and cystic character of the soft-part tumor is clearly shown.

one sees a more or less translucent, subcortical shadow with fuzzy, infiltrating outer margin. Like the benign chondroma, chondrosarcoma may be finely multilocular. The shadows of spicules of new bone may be present. Later in its course, this tumor destructively involves the cortex of the bone. The clinical course of the primary form ends usually within twenty months, while that of the secondary form extends over a much longer period.

The sclerosing, or osteoblastic, type of osteogenic sarcoma occurs in the metaphyses of the long bones of patients between fifteen and twenty-five years of age, rarely, however, in the proximal metaphysis of the humerus. There are only three such cases in this laboratory. The X-ray film is characteristic—dense, radiating, periosteal new bone ("sun ray type") and sclerosis of the marrow cavity by infiltration from the periosteal zone. Trauma usually precedes and pain accompanies these tumors, the duration of whose symptoms averages ten months.

Two additional bone-formative processes occur in the region of the humerus, but rarely. They are ossifying periostitis and myositis ossificans; the first being an affection of bone, the second, entirely separate from bone.

Ossifying periostitis is due to infection which produces thickening and increased density of cortical bone, with a consequent tendency toward obliteration of the medullary canal, and varying amounts of periosteal roughening and new bone formation.

This condition is usually found in individuals under twenty-five years of age, confined to a single bone—the tibia. The onset is of eighteen, and the almost total absence of symptoms until pathologic fracture occurs.

Giant-cell tumors are relatively infrequent

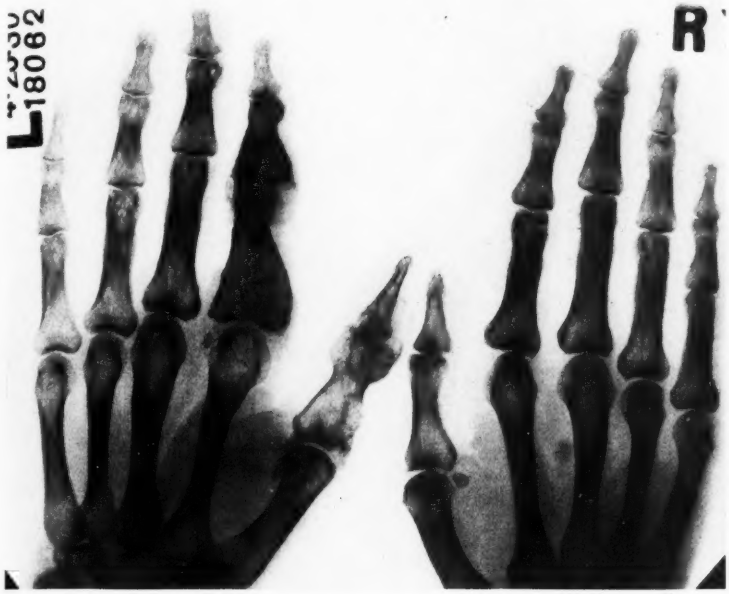


Fig. 3-*C*. Multiple benign chondromas, left thumb and forefinger, present in the same patient shown in Figures 3-*A* and 3-*B*.

acute, with subsequent abatement of symptoms.

Myositis ossificans, which sometimes follows hemorrhage into muscle, may be distinguished from a true lesion of bone by a zone of non-osseous tissue separating tumor and bone, visible in the X-ray film.

Of the tumors which, in the X-ray film, present bone destruction as their chief characteristic, all are central, and, with the exception of the chondroblastic sarcoma, all exhibit a strong tendency toward pathologic fracture.

Bone cysts, of which the upper humerus is the second most frequent site, is to be distinguished by the smooth, symmetrical expansion and thinning of the cortex (which is usually left intact), the metaphyseal location, the occurrence usually before the age in the upper humerus. The location in the epiphysis, the age of the patient (generally over twenty-five), the asymmetrical expansion with frequent perforation of the bone shell, and the usual sequence of trauma, pain, tumor, and pathologic fracture, help to identify these tumors.

Chondroblastic sarcoma, a rare tumor in any location, has occurred in the upper humerus in four cases from this laboratory. The lesion, in the region of the epiphyseal line, produces mottled, central bone destruction, with or without cortical expansion, and a definite periosteal reaction. The age of the patient is most frequently between ten and twenty. The chondroblastic sarcoma is a highly malignant tumor, two of thirty cases living five years with surgical and X-ray treatment.

The osteolytic osteogenic sarcoma is a type much more frequently encountered in the upper humerus than the sclerosing osteogenic sarcoma, as evidenced by the accompanying table. It is a tumor primarily of young adults and grows increasingly rare with advancing age. In the X-ray film there is central bone destruction involving the cortex, but without cortical expansion, and a definite periosteal reaction, which, however, does not parallel the "sun ray" effect produced by the sclerosing type.

Fig. 4-*A*. Chondrosarcoma (probably secondary to benign chondroma). Roentgenogram of the upper humerus (taken following injury), with clinical diagnosis of a pathologic fracture. Note the widened metaphysis and trabeculated structure of a chondroma. Path. No. 43,604.

Fig. 4-*B*. Roentgenogram of the same patient shown in Figure 4-*A* thirteen months later showing extensive and progressive destruction, with involvement of the periosteum pointing to a secondary malignant change at the site of the original cartilaginous lesion.

Multiple myeloma affected the upper end of the humerus in 37.5 per cent of the cases which involved any of the long bones. Its occurrence there is always indicative of a general skeletal involvement. It is a multiple tumor, exhibiting central "punched-out" areas and frequent pathologic fracture in the X-ray film. Of the cases in the files of this laboratory, there was pathologic fracture in 62 per cent. The age and clinical features are peculiarly helpful in diagnosis. The occurrence of multiple myeloma usually in the sixth decade of life and the Bence-Jones bodies in the urine, skeletal deformities, and neurological manifestations are fairly characteristic.

Metastatic tumors, including metastatic carcinoma and hypernephroma, are rather common occurrences in the upper humerus, especially when there is a single destructive metastatic lesion. Hypernephroma constitutes the chief primary tumor. Diffuse

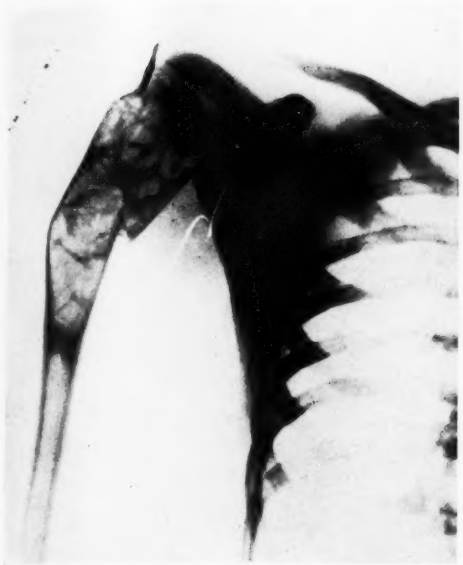


Fig. 5. Benign bone cyst. Roentgenogram of a benign bone cyst situated in the metaphysis, with smooth symmetrical expansion, thinning of cortex, and pathologic fracture.

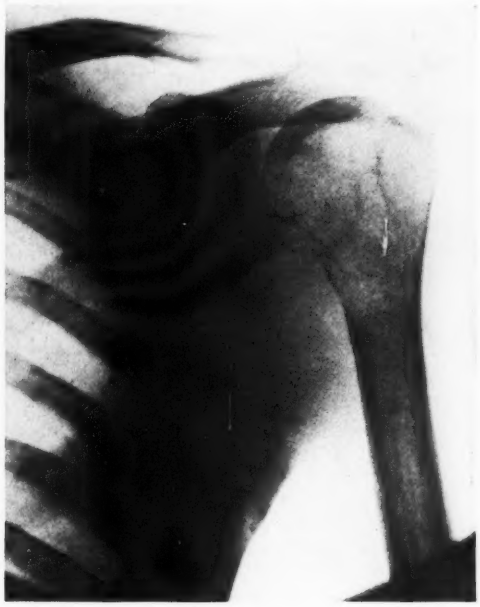


Fig. 6-*A*. Benign giant-cell tumor. Roentgenogram shows the central location in the epiphysis and the asymmetrical expansion typical of these lesions. Path. No. 28,636.

osteolytic metastases from breast carcinoma are more frequent in the spine and pelvis but are not rare in the upper humerus and region of the shoulder girdle, particularly in cases in which surgical treatment has been delayed. The diffuse osteoplastic metastases of carcinoma of the prostate rarely include the upper humerus in their distribution. The age of the patient, usually late adult life, and the demonstration of a primary malignant tumor in another location, are all important diagnostic points.

The bone destruction seen in cases of Ewing's tumor and periosteal fibrosarcoma is a secondary process. These tumors are rarely seen in the location being discussed. Ewing's tumor is characterized by its intracortical origin, with parallel endosteal and subperiosteal layers of new bone formation ("onion-peel appearance"), and occasional right-angled periosteal bone formation. Peri-

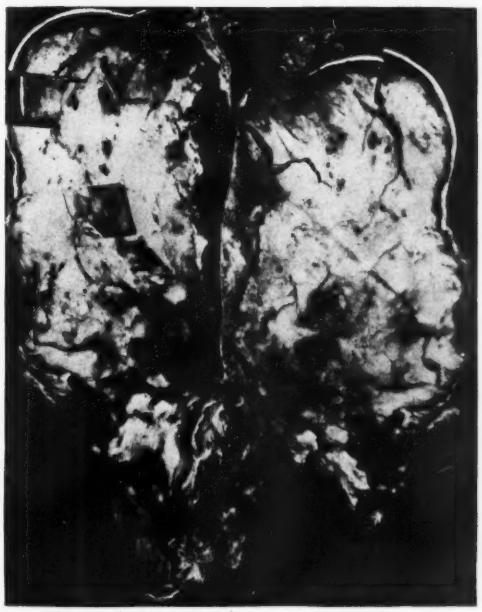


Fig. 6-*B*. Gross specimen of the tumor shown in Figure 6-*A*, demonstrating the perforation of the bone shell.

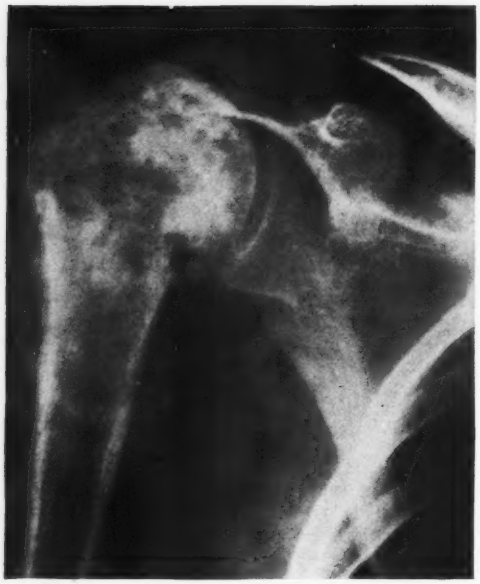


Fig. 7. Chondroblastic sarcoma. In the roentgenogram the location near an epiphyseal line, the mottled central bone destruction, and the periosteal involvement are typical. Path. No. 35,088.

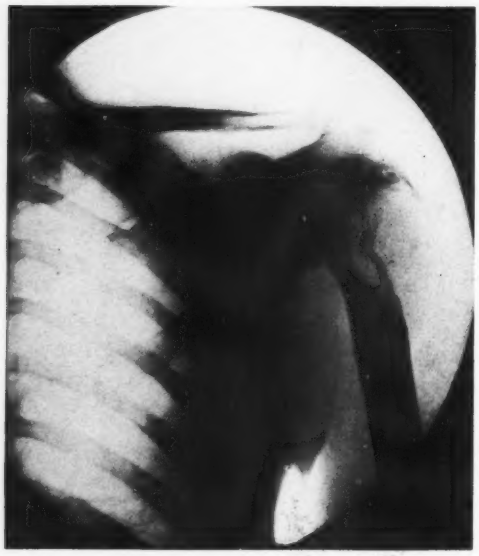


Fig. 8. Metastatic hypernephroma. Roentgenogram shows a single destructive lesion, with absence of bone formation. The shell of the bone has been perforated and the tumor has extended into the soft parts: it has also reached the epiphysis. Path. No. 42,906.

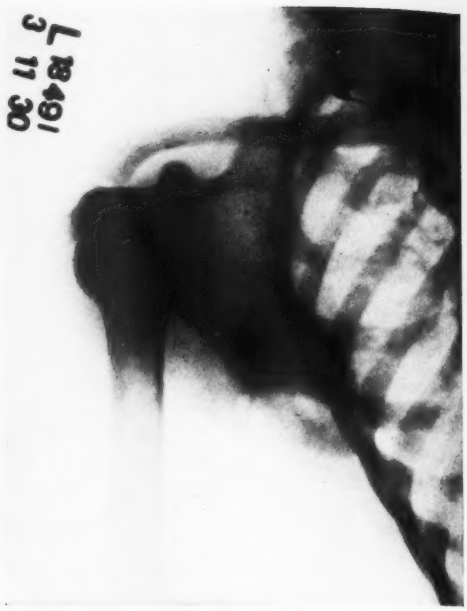


Fig. 9. Metastatic carcinoma of the prostate. Roentgenogram shows the diffuse osteosclerosis caused by metastatic carcinoma from the prostate invading the epiphysis and metaphysis of the upper humerus. Path. No. 42,182.

osteal fibrosarcoma, in the X-ray film, presents a soft-part shadow, secondarily eroding the bone beneath, and sometimes slight reactive new bone formation. Two-thirds of all the cases in this laboratory are found in patients thirty years of age or older.

These brief outlines of X-ray findings and clinical features in the lesions of the upper humerus bring out, it is hoped, certain rather definite points of differentiation.

As regards treatment of these lesions of the upper humerus, the following are important points:

1. The two most frequent osteolytic lesions do not require surgical intervention. They are the benign bone cyst and the malignant metastatic tumor, whose origin is elsewhere than in defect of bone. The bone

cyst is best left alone, or, if pathologic fracture has occurred, given light X-ray therapy. The metastatic tumor is treated best in this late stage by heavy doses of deep X-ray.

2. In all other cases in which the nature of the tumor is doubtful, the wise procedure seems to be to put the arm at rest, administer X-ray therapy, and obtain competent consultation on the X-ray films, rather than immediate exploration for microscopic examination.

3. Resection in all malignant lesions of the upper humerus offers as much for cure as does amputation and more for the patient, if cured.

Table I summarizes data obtained from analysis of the cases of upper humeral lesions from the Surgical Pathological Laboratory of the Johns Hopkins Hospital. Sclerosing osteogenic sarcoma and chondrosarcoma have been grouped together as periosteal sarcoma; osteolytic osteogenic and chondroblastic sarcoma, as central osteolytic sarcoma.

TABLE I

Tumor	No. cases occurring in upper humerus	Most frequent site in long bones	Total no. cases occurring in long bones	Percentage of total no. cases in long bones occurring in upper humerus
Exostosis	22	Lower femur	181	12.2
Chondroma	2	Upper humerus Lower femur	7	28.5
Bone cyst	32	Upper femur	135	23.7
Giant-cell tumor	9	Lower radius	145	6.2
Periosteal sarcoma Chondrosarcoma 18 Sclerosing osteogenic sarcoma 3	21	Upper tibia	128	16.4
Osteolytic sarcoma Osteolytic osteogenic sarcoma 13 Chondroblastic sarcoma 4	17	Lower femur	106	16.0
Fibrosarcoma	1	Upper tibia	13	7.7
Ewing's tumor	2	Upper femur	56	3.6
Multiple myeloma	6	Upper femur	16	37.5
Metastatic tumor	15	Upper femur	96	15.6
Ossifying periostitis	6	Upper femur	75	8.0
Myositis ossificans	1	Upper femur	20	5.0
	134		975	

Total malignant lesions..... 62
Total benign lesions..... 72
Percentage malignant..... 46

TUMORS OF THE OS CALCIS

By JOHN R. MOORE, M.D., Shriners' Hospital, PHILADELPHIA, PENNA.

From the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University

TUMORS of this bone are comparatively rare. Very recently Dr. Joseph C. Bloodgood and his staff at the Surgical Pathology Department, Johns Hopkins Hospital, studied some seventeen hundred bone tumors with special reference to anatomical location. Thirty-three, or approximately 2 per cent, involved the calcaneum. It is the intention at this time to briefly analyze these tumors with reference to age, incidence, symptomatology, pathology, and treatment, and to include a brief review of the tumors occurring in the literature.

One might expect newgrowths in this area to be rather common if trauma were consid-

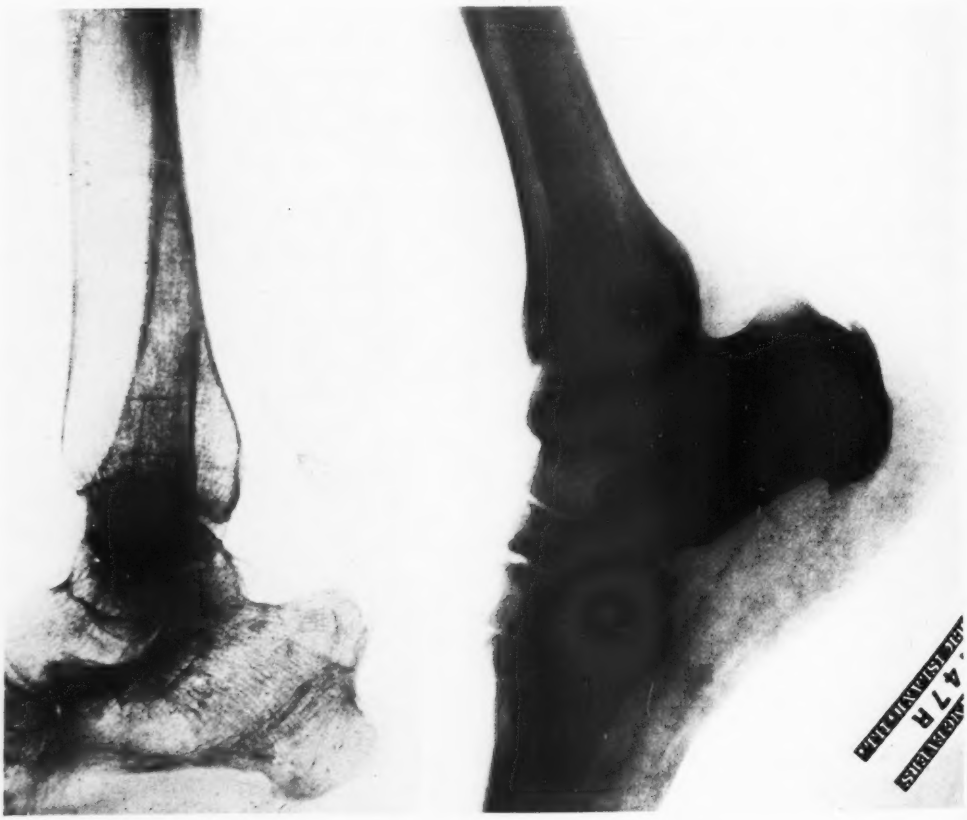


Fig. 1. Roentgenogram showing an exostosis of the os calcis. There is a rather large calcified area in the tendo achillis just above its insertion. Two bony growths are present, similar in shape and location to those shown in Figure 2.

Fig. 2. Roentgenogram showing exostoses on the os calcis. Note the beak-shaped spur located at the tendo achillis insertion and a small "rose thorn growth" on the plantar tubercle. The base or pedicle of these small tumors is wide and appears to be a part of the normal bone structure of the os calcis. This is the principal diagnostic feature of exostosis.

ered a very important etiologic factor. The os calcis forms a rather fixed pillar of the longitudinal arch; frequently it is forced to carry the entire weight of the body, as in jumping or falling and landing on the feet.

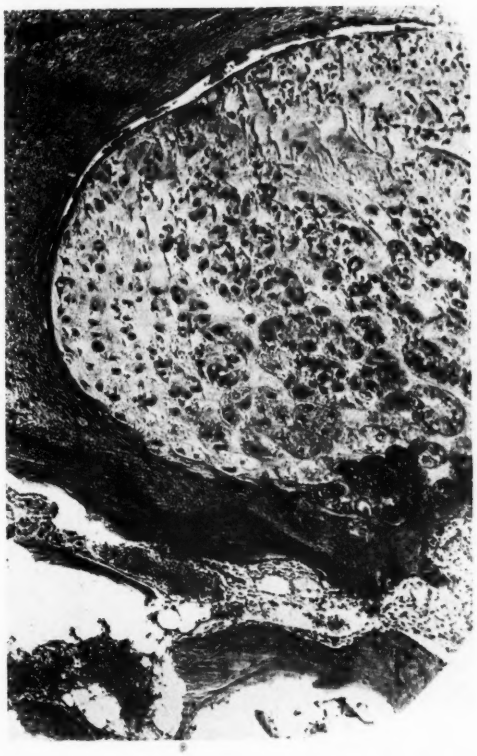


Fig. 3. Photomicrograph showing a typical low-power picture of an exostosis. The first layer (from above downward) is one of primitive connective tissue; a second layer represents normal adult cartilage which is undergoing calcification in its deeper layers; below this is seen normal cancellous bone enclosing islands of fatty bone marrow.

It is constantly exposed to the irritation of ill-fitting shoes. Scudder remarks that it is the most frequently fractured bone in the foot. From the standpoint of anatomy and development and to some extent the behavior and types of the tumors frequently involving it, one's attention is called to its very close resemblance to the long pipe bones, *i.e.*, the femur, tibia, etc. It is preformed in cartilage, has an ossification center for the body and one for the apophysis and plantar calcaneo-tubercles. The latter two unite with the body about the fifteenth year, paralleling the osteogenesis noted in the long bones. It is covered by true periosteum. Two powerful tendons, the Achilles and the tibialis posticus (in part), insert in it; place of origin is also given to the plantar structures.

Ewing's tumor, most commonly found in the long pipe bones, involved the calcaneum twice in this series and four times in cases reported in the literature. Chondromas

occurring in the os calcis progress very much like the chondromas of the long bones and must be watched carefully for malignant changes. Geschickter (1) has emphasized the behavior of this type of tumor in the calcaneum in 1885; Fahlenbock (5), a giant-cell sarcoma of the os calcis in 1894, while in 1914 W. P. Coues described what was probably the first bone cyst of the os calcis to be reported.

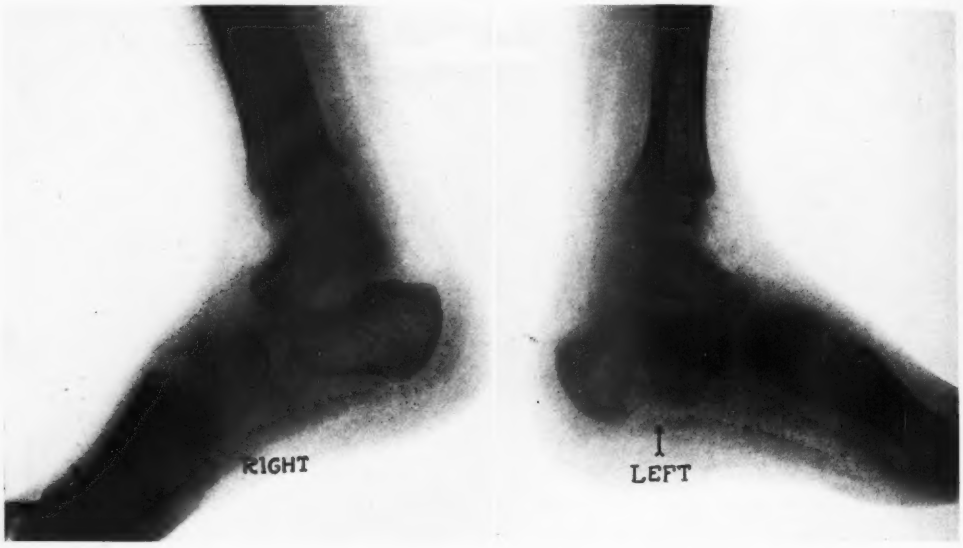


Fig. 4-*A*. Roentgenogram showing chondroma of os calcis. Note the central rarefied area. Bone shell is intact. There are no trabeculations such as are so often seen in the giant-cell tumor and the healing bone cyst.

the os calcis and has stressed its possible malignant tendencies in contrast to the cartilaginous tumors occurring in the metatarsals and phalanges, which are nearly always benign.

Ninety-one tumors of the os calcis were found in the literature for the past fifty-one years. Of this group, 67 were benign exostoses, one chondroma, four bone cysts, four giant-cell tumors, two chondrosarcomas, four Ewing's endothelial myelomas, eight sarcomas (unclassified), and two epitheliomas.

Briggs (2) reported an epithelial growth of the heel involving the os calcis in 1883; S. Bayer (3), a round-cell sarcoma of the os calcis in 1883; Jeannel (4), a chondroma of

Literature on exostoses probably antedates that on all other tumors of the os calcis. W. S. Baer (6), in 1907, and Meisenbach (7), in 1911, were among the first to make a detailed study of these growths.

Table I shows the tumors occurring in the foot. Of 78, the total number, 32 (or 41 per cent) occur in the os calcis. Exostosis is the predominant lesion in the os calcis, phalanges, and metatarsals. The giant-cell tumor is most common in the tarsals. It is interesting to note that metastatic tumors involved the tarsals, metatarsals, and phalanges but never were found in the os calcis. No report of metastases to the os calcis was found in the literature.

STUDY OF THE VARIOUS TUMOR GROUPS

Exostoses.—There were 262 cases of exostoses among the 1,740 bone tumors. Of these, 9 per cent (or 23) occurred in the os calcis. Twenty-one were in males; two were in females. Of the patients, 22 were white and one colored. The average age was from twenty-five to thirty-five years; the oldest case was sixty-five, the youngest ten. Pain preceded discovery of the tumor from six months to one year. One spur was located near the attachment of the tendo achillis and the remainder appeared on or between the plantar tubercles; as judged from the X-ray films. In this particular series all were treated by excision—three recurred. The microscopic pictures were typical of an exostosis (see Fig. 3). Trauma and infection contributed about equally to the etiology.

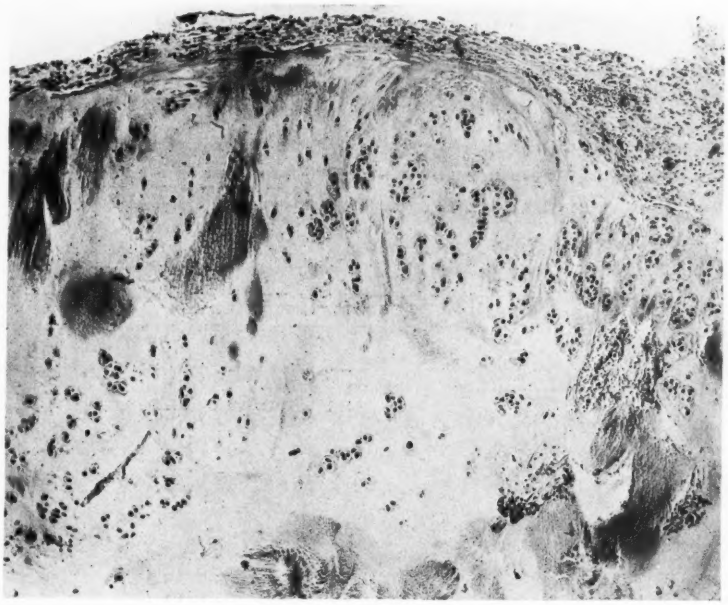


Fig. 4-*B*. Photomicrograph showing a typical low-power section of a chondroma. The cartilage cells and stroma are of the normal adult type.

TABLE I

ANALYSIS OF THE THIRTY-TWO TUMORS OF THE OS CALCIS STUDIED AT THE JOHNS HOPKINS SURGICAL PATHOLOGICAL LABORATORY

	Os Calcis	Tarsus	Metatarsals	Phalanges
Exostosis	23	3	3	11
Chondroma	2	0	0	6
Bone cyst	0	1	1	0
Giant-cell tumor	2	4	2	1
Chondrosarcoma	3	3	1	1
Ewing's tumor	2	0	1	2
Metastatic carcinoma	0	2	2	2
Total	32	13	10	23

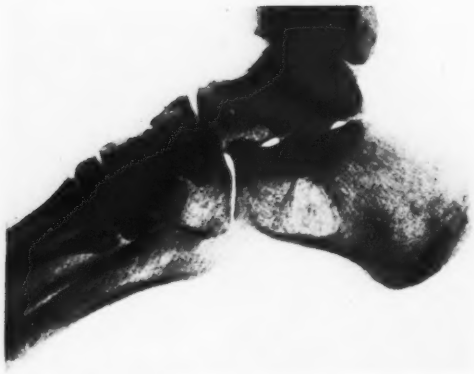


Fig. 5. Central expanding defect in the os calcis. *(Reproduced by permission from Jour. Bone and Joint Surg., April, 1930, XII, 416.)*

To quote C. F. Geschickter:[1]

"Histogenically these tumors are considered to be an exaggeration of a normal bony protuberance intended for the anchoring of an important tendon. At such a junction

[1]C. F. Geschickter: Bone Tumors of the Fibrocartilaginous Group. To be published in *Archives of Surgery.*

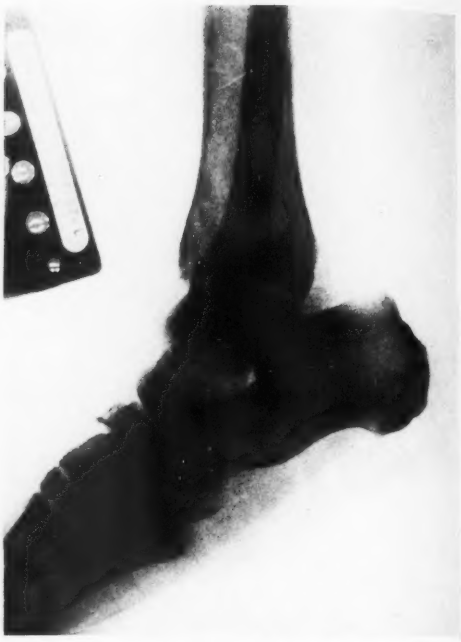


Fig. 6-*B*. Roentgenogram of left os calcis taken for comparison with Figure 6-*A* (same case).

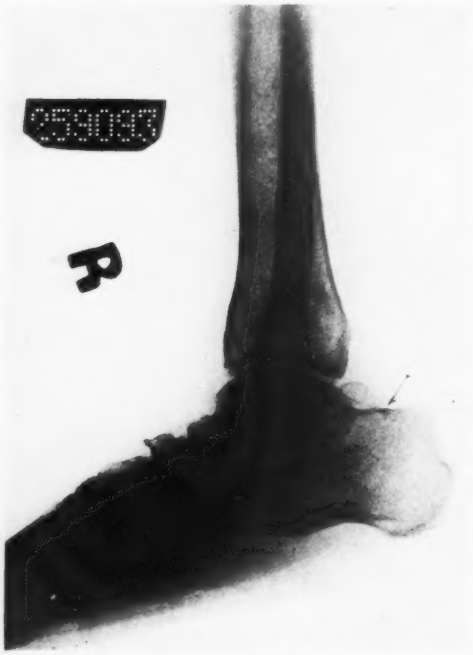


Fig. 6-*A*. Roentgenogram of right os calcis taken ten days after trauma. There are two very small areas of rarefaction near the center of the calcaneum.

Fig. 6-*C*. Typical roentgenogram of a giant-cell tumor. Right os calcis ten months after injury. There is an expanding central tumor, with marked bone destruction. Trabeculation is present. Same case as shown in Figures 6-*A* and 6-*B*.

Nature provides normally for a protuberance of bone bulging through a gap in the periosteum to meet an adjoining tendon, which co-operates in the formation of the attachment by cartilaginous ossification within the substance of the tendon. An exostosis represents a failure in the accurate approximation of the tissues entering into such a junction, the cartilaginous center in the tendon persisting in the form of primitive connective tissue, proliferating in excess, and the protuberance of normal bone beneath extending to form a pedicle or base."

Spurs are most commonly found on the plantar tubercles, secondarily at the insertion of the tendo achillis, and third in order of frequency at the insertion of a slip of the tibialis posticus. Figures 1 and 2 represent the first-mentioned locality, while Figure 3 shows a low-power microscopic view of an exostosis. With one exception, all the exostoses in this series appeared as rather small spur-like processes, which appears to be rather typical of the cases reported in the literature with so-called infectious origin. However, there exists probably another type, not represented in this series, which has an appearance more similar to the congenital exostosis frequently seen in the long bones. Kurtz, of Philadelphia, and Lewin, of Chicago, both have reported tumors probably of this type. In several cases of multiple exostoses reviewed, none involved the os calcis. Whitmore and Smith, writing in the *U. S. Naval Medical Bulletin*, reported a case with multiple exostoses, seventy-two in number, but the os calcis was not involved.

Chondromas.—There were two classes of chondroma involving the os calcis, in white males, aged nineteen and twenty-five years, respectively. Pain and tumor were the principal symptoms. Following curettage, one remained well for four years; the second had recurrences and amputation was advised. Figure 4-*A* represents a chondroma of the os calcis and Figure 4-*B* is a typical microscopic picture.

Fig. 6-*D*. Roentgenogram of right os calcis taken sixteen months after injury, showing that the tumor has doubled in size. The bone shell has been perforated and soft parts are invaded. Same case as shown in Figures 6-*A*, 6-*B*, and 6-*C*.

Bone cysts.—No bone cysts were found in this series. Figure 5 is a reproduction of a reported case.[2]

Giant-cell tumor.—Three cases (two males, one female) occurred in this series. The age averages from thirty to forty years in this group of tumors. Symptoms of intermittent pain, swelling, and tumor are common, their average duration being fifteen months. Two cases were treated by curettage and the patients are well after five years; in one, resection was performed and the patient is well, four months after resec-

[2]Used by permission; N. R. Smith, Cyst of Os Calcis. Jour. Bone and Joint Surg., April, 1930, XII, 416.

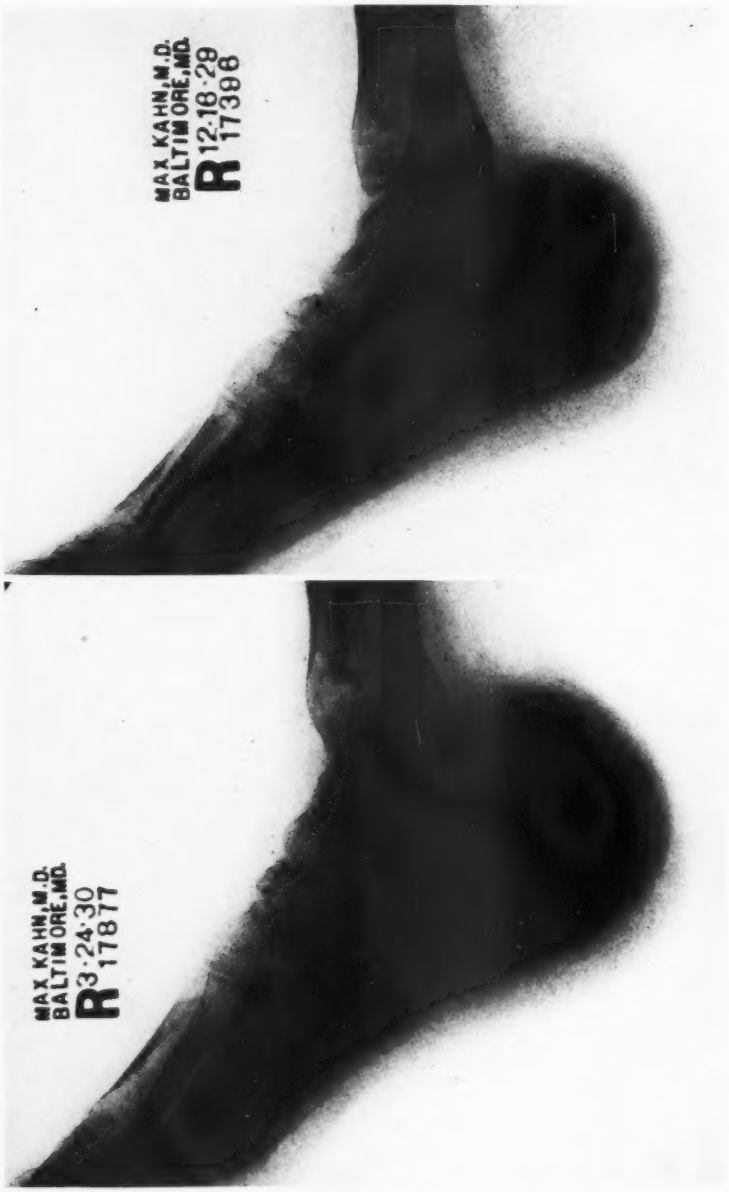


Fig. 6-*E (above).* Roentgenogram showing the os calcis eighteen months after the injury. Patient had just completed two months of intensive deep X-ray therapy. The growth was not checked and the entire posterior two-thirds of the calcaneum is now destroyed. Some trabeculation is present along the plantar surface and probably represents a reaction to the X-ray therapy. Same case as shown in Figures 6-*A*, 6-*B*, 6-*C*, and 6-*D*.

Fig. 6-*F (below).* Roentgenogram of same case taken nineteen months after the injury, showing almost complete replacement of the os calcis by tumor.

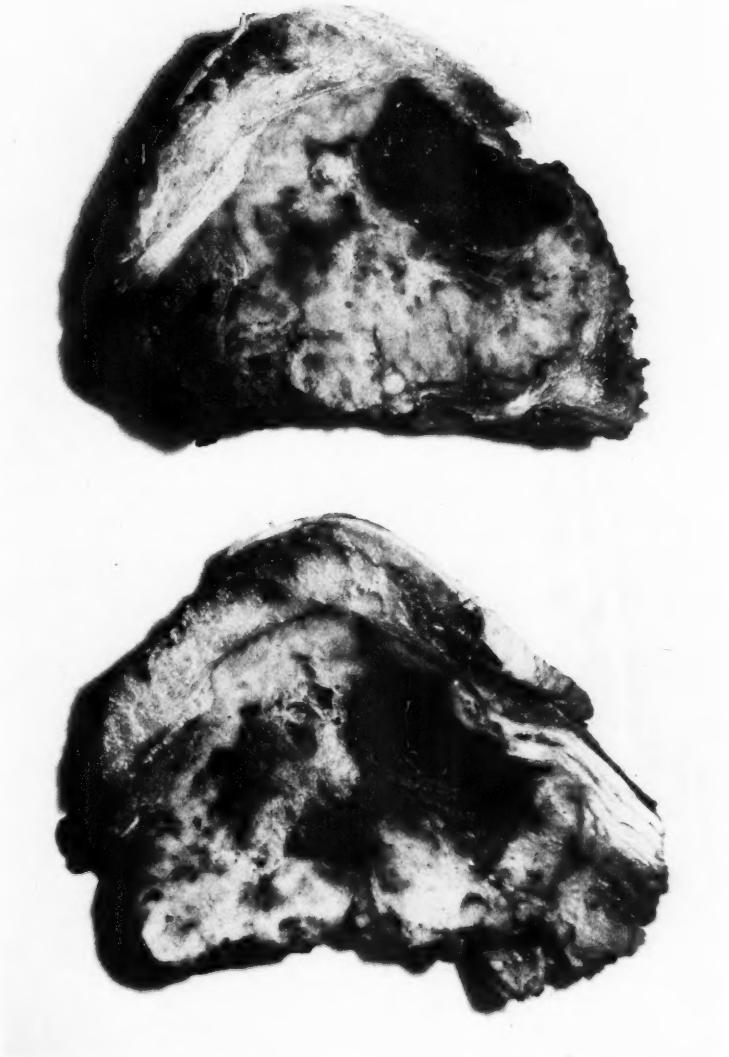


Fig. 6-*G*. Photograph showing a sagittal section through the gross specimen. Note the grumous nature of the tumor, the areas of hemorrhage and cystic degeneration.

tion. Figures 6-*A* to 6-*I*, inclusive, show the case treated by resection of the os calcis. This series of X-ray films is quite unusual in that it represents probably the complete history of a tumor from origin with trauma, rapid growth period, almost complete destruction of the os calcis, refractoriness to X-ray therapy, and cure by excision of the os

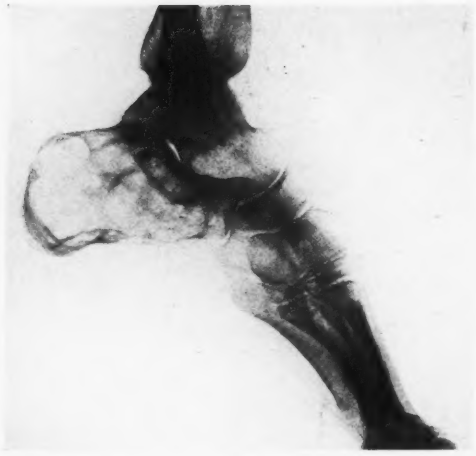


Fig. 7. Roentgenogram showing a rather typical slow-growing giant-cell tumor of the os calcis. There are areas of destruction without any evidence of bone production. Trabeculation is quite marked. The bone shell is intact.

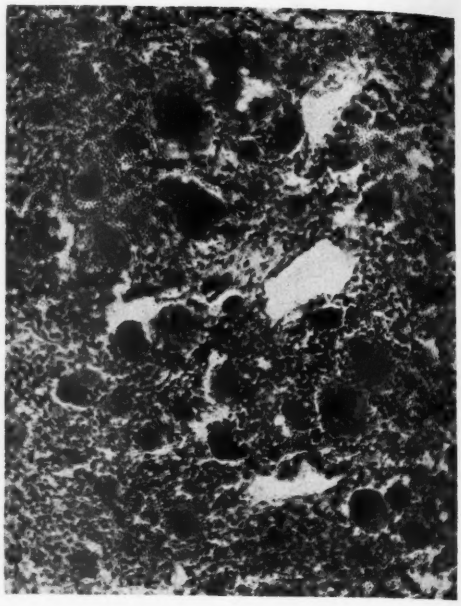
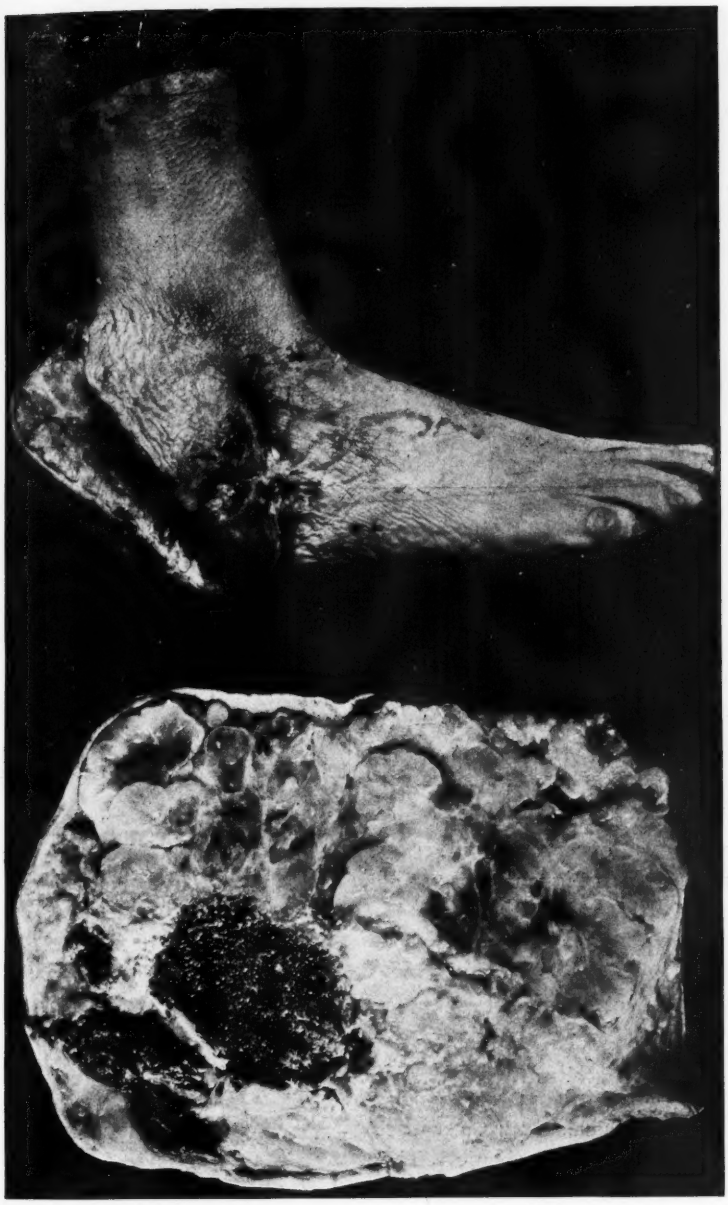


Fig. 8. Photomicrograph of low-power section of the giant-cell tumor. Note the numerous giant cells that predominate in a stroma of small round cells.

calcis. Note that the first X-ray film was taken ten days after the patient had received a rather minor injury to the right os calcis. There was a perfectly negative history prior to this time. Figure 6-*E* shows the tumor after twelve deep X-ray treatments: the growth was not checked. Figure 7 is a giant-cell tumor of the os calcis of very slow growth. Note the trabeculation and intact bone shell. This case was cured by curettage.

Chondrosarcoma of the os calcis.—There were three cases (ages 31, 43, and 56 years, respectively), all in white males and all secondary to a preceding chondroma. The symptoms included pain and tumor and the treatment was amputation. The results showed: one patient well for five years, one living for three years, with recurrence, and one dead. All of these cases represent malignant changes in a chondroma. The sections, typical of chondrosarcoma, show fetal cartilage and myxomatous tissue. Figure 8-*A* shows a gross specimen of the os calcis. Figure 8-*B* is a roentgenogram of the same specimen, and Figure 8-*C* is the high-power photomicrograph.

Ewing's tumor.—There were two cases in this group. Case 1, aged 14, was a white female, with pain and tumor of the os calcis of twenty-four months' duration. The X-ray examination showed a marked sclerosis of the os calcis, at first diagnosed as chronic non-suppurative osteomyelitis. The lesion was incised and drained, followed later by amputation, and finally resulting in death. Figures 9-*A* and 9-*B* show this case of very marked sclerosis of the os calcis. Figure 9-*C* is the photomicrograph. Case 2 was a white male, aged 39 years, with pain and tumor of twenty-four months' duration. The X-ray film showed marked destruction of bone. The diagnosis was made by biopsy. Amputation was followed by death in five months. The



Figs. 9-*A* and 9-*B*. Chondrosarcoma of os calcis. A photograph of the foot and the gross specimen removed by amputation. The section is sagittal. Observe the cartilaginous tumor surrounding the os calcis. The calcaneum has been destroyed for the most part. Lobulation of the cartilage mass can be easily seen.

microscopic sections showed a typical Ewing's sarcoma.

SUMMARY

Of 1,740 tumors reviewed at Johns Hop-

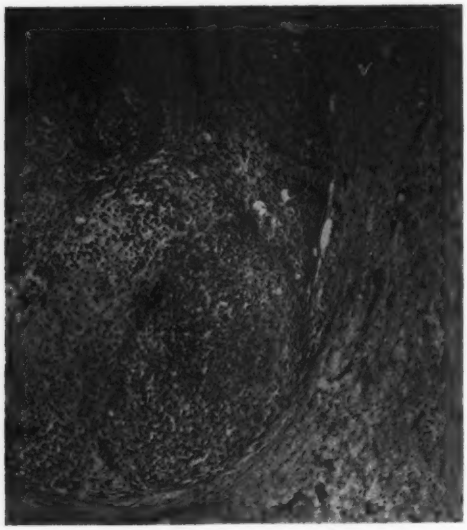


Fig. 9-*C*. Photomicrograph showing typical high-power section of chondrosarcoma. Note the fetal cartilage cells and myxomatous areas lying in a stroma of embryonic connective tissue. (See Case 2, under "Ewing's tumor.")

kins Surgical Pathological Laboratory, 33 (or 2 per cent) involved the os calcis. Exostosis was the most common newgrowth, occurring in 23 of the total number. All were treated by excision; twenty were cured, three recurred. No malignant changes appeared in this series. Dr. Geschickter has informed me that he has one exostosis of the os calcis in which a chondrosarcoma (?) developed. Chondroma, giant-cell tumor, chondrosarcoma, and Ewing's tumor compose the remainder. No bone cysts, myeloma, or metastatic tumors were found. Chondromas of the os calcis must be treated as chondromas of the long bones. They should be watched carefully, with frequent X-ray examination, and the malignant possibilities constantly borne in mind. If malignant changes are in evidence, they must be treated as chondrosarcoma. Early amputation offers the only hope. The giant-cell tumors, if recognized before the shell is perforated, respond to curettage and apparently have little tendency to recur. Excision or amputation may be necessary when soft-part invasion is extensive. Ewing's tumor offers little hope for life, if one may judge by the two cases reported. However, in both cases diagnosis was not made for twenty-four months. It is possible that with early diagnosis amputation and X-ray therapy might have helped.

BIBLIOGRAPHY

(1) Geschickter, C. F.: Bone Tumors, Fibrocartilaginous Group. (To be published in Archives of Surgery.)

(2) Briggs, W. T.: Epithelial Growth of the Heel: Removal, Together with Resection of Portion of Os Calcis. Nashville Jour. Med. and Surg., March, 1883, XXXI, 135.

(3) Bayer, S.: Ett fall af storcelligt alveolärt rundcellsarkom i hälen. Upsala Läkaref., 1883, XVIII, 103.

(4) Jeannel: A propos d'une observation du chondrome du calcaneum. Rev. med. de Toulouse, 1885, XIX, 521.

(5) Fahlenbock, W.: Centralis Riesenzellen sarkom des calcaneus. Deutsche Ztschr. f. Chir., 1895, XLII, 175.

(6) Baer, William S.: Gonorrheal Exostoses of Os Calcis. Surg., Gynec. and Obst., February, 1906, II, 168.

(7) Meisenbach, Roland O.: Pathogenesis of Spur Formation on Os Calcis. Am. Jour. Orthop. Surg., 1911, IX, 457.

(8) Morestin, H.: Sarcome du Calcanéum. Bull. et. mém. Soc. Anat. de Paris, April, 1899, LXXIV, 346.

(9) Cameron, H. C.: Sarcoma of Os Calcis. Trans. Glasgow Path. and Clin. Soc., 1899, VIII, 75.

(10) Abadie, Jules: Cas de Sarcome du Calcanéum. Arch. Prov. de Chir., Paris, December, 1903, XII, 729.

(11) Martin, A. M.: Resection of Os Calcis for Sarcoma. Northumberland and Durham Med. Jour., Newcastle-on-Tyne, 1905, XIII, 71.

(12) Bradford, E. H.: Exostosis in Plantar Portion of Os Calcis. Am. Jour. Orthop. Surg., April, 1907, IV, 392.

(13) Worms and Hamant: Osteosarcome du Calcanéum. Bull. et mém. Soc. Anat. de Paris, February, 1912, LXXXVII, 104.

(14) Coues, William P.: Case of Bone Cyst of Os Calcis. Boston Med. and Surg. Jour., April 16, 1914, CLXX, 611.

(15) Swett, Paul P., and Stoll, Henry F.: Hereditary Syphilis as Etiological Factor in Spurs on Os Calcis. Surg., Gynec. and Obst., June, 1916, XXII, 674.

(16) Marshall, H. W.: Case of Multiple Cartilaginous Exostoses. Am. Jour. Orthop. Surg., June, 1916, XIV, 346.

(17) Meyerding, H. W.: Chondromas. Jour. Orthop. Surg., February, 1920, II, 77.

(18) White, J. Renfrew: Case of Multiple Pulsating Bone Tumors. British Jour. Surg., 1921, IX, 458.

(19) Trawick, John D.: Multiple Osteochondromata in Mother and Son. Kentucky Med. Jour., July, 1921, XIX, 424.

Fig. 10-*A (above)*. Ewing's endothelial myeloma of os calcis, showing rather characteristic osteosclerosis that predominates in certain stages of Ewing's tumor and is often mistaken for non-suppurative osteomyelitis. There are occasional small areas of bone destruction. On the plantar surface there is some new periosteal bone production laid down parallel to the long axis of the os calcis.

Fig. 10-*B (below)*. Roentgenogram of same case shown in Figure 10-*A*, three months later. Bone destruction is now becoming more noticeable. Osteosclerosis is not quite so pronounced. The foot at this time has just been removed by a disarticulation at the ankle joint.

(20) BETTMAN, H. J.: Ostitis Fibrosa des Fersenbeins. Ztschr. f. Orthop. Chir., 1921-22, XLII, 309.

(21) GREENOUGH, ROBERT B., SIMMONS, CHANNING C., and HARMER, TORR W.: Bone Sarcoma: Analysis of Cases Admitted to Massachusetts General and Collis P. Huntington Memorial Hospitals from January 1, 1911, to January 1, 1921. Jour. Orthop. Surg., November, 1921, III, 602.

(22) WIDMANN, BERNARD P.: Multiple Osteochondromata. Am. Jour. Roentgenol., August, 1921, VIII, 462.

(23) BECK, EMIL G.: Sarcoma of Heel and Groin. Internat. Clinics, 1922, Ser. 32, I, p. 126.

(24) FRIEBEL, PAUL: Chondrosarkom des Calcaneus. Bruns' Beitr. z. klin. Chir., 1924, CXXXI, 167.

(25) VAUGHAN, ROGER T.: Traumatic and Bone Surgery. Jour.-Lancet, February, 1924, XLIV, 49.

(26) CHRISTENSEN, F. C.: Bone Tumors. Ann. Surg., June, 1925, LXXXI, 1074.

(27) LEWIN, P.: Calcaneal Spurs. Arch. Surg., January, 1926, XII, 117.

(28) WHITMORE, W. H., and SMITH, O. A.: Multiple Osteomata. U. S. Naval Med. Bull., October, 1927, XXV, 875.

(29) HADDA, S.: Chondrosarkom der Calcaneus. Bruns' Beitr. z. klin. Chir., 1927, CXXXIX, 197.

(30) CORDES, E.: Ueber Ostitis Fibrosa am Fusskelett. Bruns' Beitr. z. klin. Chir., 1928, CXLIII, 127.

(31) WADE, H. K.: Exostoses Occurring on Os Calcis as Result of Gonococcal Infection. Jour. Urology, August, 1928, XX, 259.

(32) KURTZ, A. D.: Unusual Bony Growth Originating from Os Calcis. Jour. Bone and Joint Surg., July, 1929, XI, 586.

(33) SMITH, N. R.: Cyst of Os Calcis. Jour. Bone and Joint Surg., April, 1930, XII, 416.

(34) PRINCE, HOWARD L.: Giant-cell Tumor of Os Calcis. Am. Jour. Orthop. Surg., November, 1916, XIV, 641.

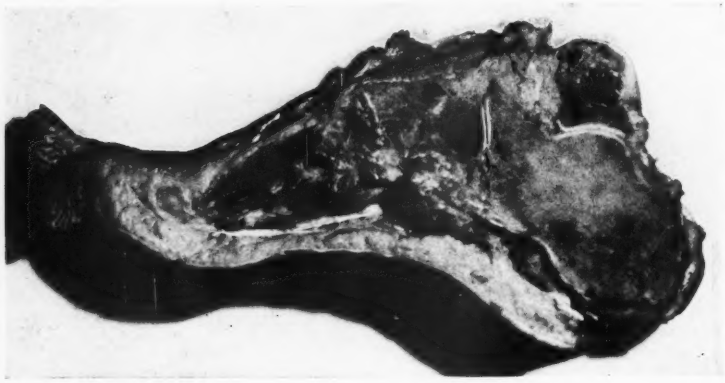


Fig. 10-*C*. Photograph showing sagittal section of the gross specimen. (Same case as shown in Figures 10-*A* and 10-*B*.) Note the strikingly increased density in the anterior two-thirds of the os calcis and the areas of destruction and hemorrhage in the posterior third.

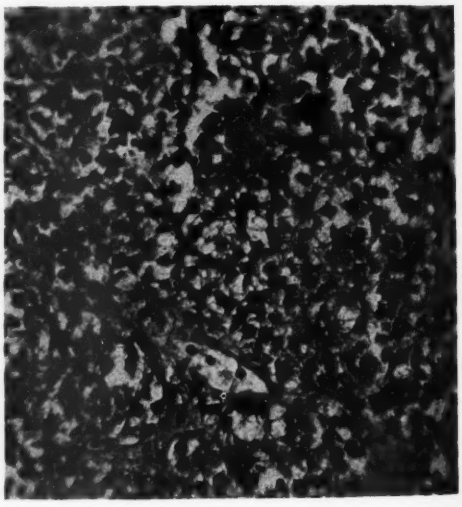


Fig. 10-*D*. Photomicrograph showing a typical high-power section of Ewing's tumor. Note that small round cells predominate and very little stroma exists.

BONE LESIONS OF THE LOWER RADIUS

By ROBERT LEE OLIVER, M.D., BALTIMORE, MARYLAND
From the Surgical Pathological Laboratory of the Johns Hopkins University

THE radius, the lateral and shorter bone of the forearm whose rotation pronates and supinates the hand, and the pathological variations of its lower end, are considered in this report. This bone is easily palpable in its entire course, though deep pressure is necessary in its mid-portion. Deformity and loss of function of this part are of inestimable importance and it is for this reason that the present study is being made, in the hope that diagnosis of the lesion may be the more accurately arrived at and the correct treatment advised for the preservation of function of the arm and hand.

In the accompanying table, the relative frequency of the different types of bone lesions found in the lower end of the radius is compared to the total number of lesions of each different type. In over two thousand bone lesions there were but 56 cases in which the lesion was found in the radius, and of these, 50 were in the lower end, representing about 90 per cent of the cases. The following is the order of frequency of involvement in the long bones—femur, tibia, humerus, radius, fibula, and ulna.

In this whole group, then, there were 45 central lesions and 5 periosteal lesions as portrayed by the X-ray. There were only 4 malignant lesions. The percentage of cures in the giant-cell tumor may seem

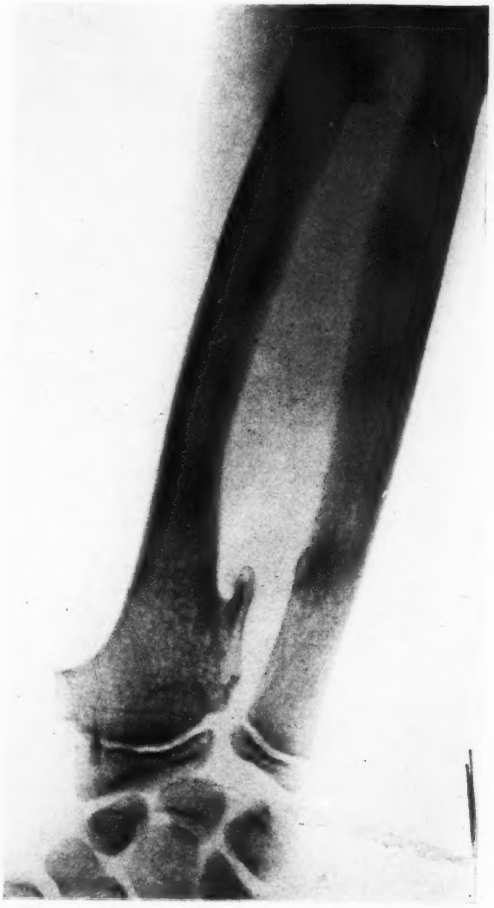


Fig. 1. Forearm of a young patient with hereditary deforming chondrodysplasia. There are multiple exostoses, the most pronounced of which is in the lower end of the radius.

TABLE I

Type	Total number cases	Radius		Percentage	Cured (percentage)
		Central	Periosteal		
Non-suppurative osteomyelitis	106	3	..	6	100
Exostosis (Multiple 10, in radius 2)	262	..	4	8	100
Chondroma	71	1	..	2	100
Bone cyst	151	3	..	6	100
Giant-cell tumor	226	35	..	70	74
Chondroblastic sarcoma	21	1	..	2	0
Ewing's tumor	70	1	..	2	0
Osteolytic sarcoma	93	1	..	2	0
Sclerosing sarcoma	63	..	1	2	0

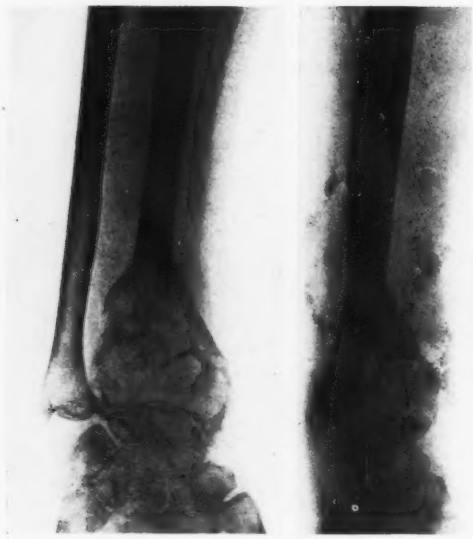


Fig. 2-*A*. Roentgenologic study in a case of recurrent giant-cell tumor in the lower end of the radius, showing the lesion before operation. Note the advanced bone destruction and the perforation of the bone shell.

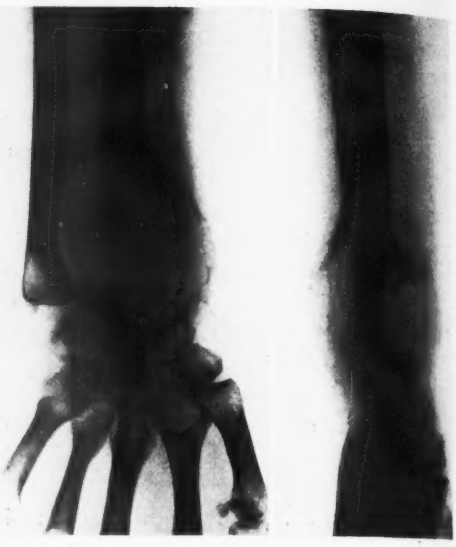


Fig. 2-*B*. Same case, showing recurrence after the first curettage. Note the absence of ossification.

small, but this will be discussed under the individual types. The various groups as outlined above must now be considered individually.

NON-SUPPURATING OSTEOMYELITIS

The frequency of non-suppurating osteomyelitis in the radius is relatively small. The X-ray appearance, according to Cohn, varies from osteoporosis to sclerosis, with all intervening grades and the admixture frequently of both osteoporosis and sclerosis. In his series of cases there were questionable diagnoses between this condition and sarcoma in 33 per cent of the cases. The age incidence is the same as that of sarcoma. The duration of the disease formerly aided in the diagnosis, but now cases are coming under observation earlier and this increases the difficulty in diagnosis. The X-ray film may show evidences of bone formation similar to the spurs seen in a simple exostosis and more advanced states, when the shaft is almost completely surrounded by new bone formation, and finally may make itself conspicuous by its presence as a subperiosteal growth. Wherever there is bone destruction along with the sclerotic process there is increased difficulty in diagnosis. As to treatment, again we quote Cohn: "When the X-ray suggests sarcoma, and the tumor is resistant to irradiation, and where the foci of infection are ruled out, an exploratory operation is justifiable provided the tumor, if malignant, is operable."

In the study of the cases occurring in the radius, three patients with non-suppurative osteomyelitis were found, aged, respectively, fourteen, seventeen, and twenty-three —well within the usual age limits. All of these cases had two or more bones involved. The duration of the condition in the three cases varied from eighteen months to seven years. The extremely chronic case was syphilitic and improved after anti-syphilitic treatment. The second patient of this group had had a typhoid infection four years pre-

viously, was not operated upon, and remains unimproved after a number of years. The last case gave a history of eighteen months' duration. At operation, the microscopic examination revealed nothing but granulation tissue. This patient has been well for a period of seven years.

The percentage of cures in this general group of non-suppurative osteomyelitis is about 90 per cent. Two cases out of the group were recurrent, ten were progressive, and three proved malignant in the years following. None of these unsuccessful cases, however, occurred in the lower radius.

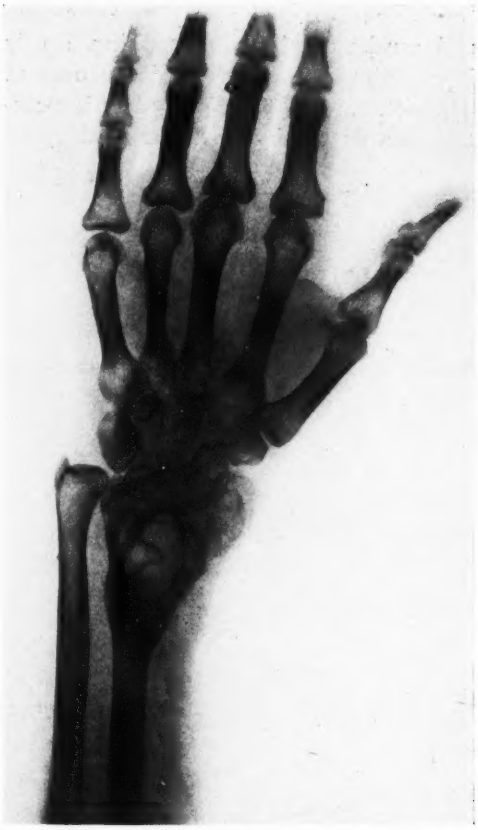


Fig. 2-*C*. Same case, showing recurrence after the second curettage. There has been re-ossification and healing, except at the styloid process of the radius.

EXOSTOSIS

Exostoses are found usually near the ends of the long bones; in the radius, however, they are comparatively infrequent. This condition occurs usually between the ages of ten and twenty-five and consists of a bony spur covered by adult cartilage. Patients are frequently asymptomatic, but the growth may make itself conspicuous by a painless swelling near a joint or by a stiffening of the joint. The X-ray film reveals an outgrowth of cancellous and compact bone merging imperceptibly with the normal bone of the shaft. The microscopic findings are normal adult bone and cartilage.

There were, in all, 262 cases of exostoses, of which 70 per cent occurred in the long bones of the extremities. Seven cases were in the radius, with four in its lower end. Twenty-two out of the entire number were multiple. Two of the four cases in the lower radius were multiple—one patient, a girl of ten, came from a family in which there was a history of three similar cases. All of the cases presented pedicle exostoses in the X-ray examination. In two cases no operation was done, in one a biopsy, and in the other an excision. All the patients have remained in good health for from four to ten years. One must conclude from this that with careful observation of the progress of the exostosis, with occasional X-ray examination in cases in which deformity is not too marked and the function is undisturbed, no treatment is necessary unless there is undue increase in the size of the tumor and its presenting symptoms. If necessary, the operation of choice is simple excision. Only 5 per cent of this general group shows later malignant change. It is interesting to note here that when multiple exostoses do occur, the fibula or radius is affected.

CHONDROMA

Benign chondromas are usually central and occur chiefly in the small bones of the

hands and feet. The symptoms are mild and consist usually of a swelling, slowly increasing in size, with occasional soreness. The picture seen on the X-ray film is a central area of rarefaction surrounded by an expanded shell of cortical bone. Removal of the tumor by excision or curettement, with chemical or thermal cauterization, is sufficient, but incomplete removal tends towards recurrence, which may or may not assume malignant characteristics. The histologic picture is that of adult cartilage interspersed with strands of connective tissue. Frequently this type of tumor is not pure in form but is mingled with myxoma. The prognosis is good.

The cases in this group number 71. Chondromas of the long bones are rare. Of the series, only six cases were found in the long bones of the extremities and only one of these in the radius. This was a case in which there was chiefly a hypertrophy of the joint cartilage. This small tumor was removed by simple excision and the patient is now well, with no recurrence.

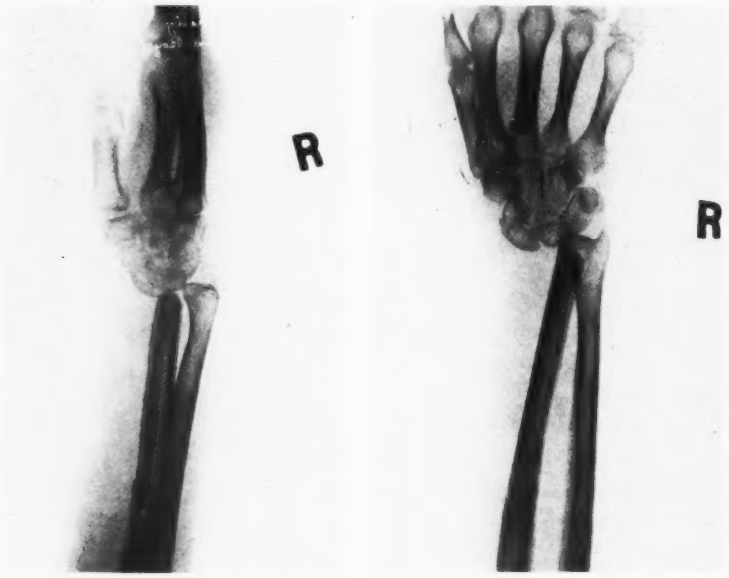


Fig. 2-*D*. Same case, showing transplant after resection. Function has been restored, but there is marked ulnar deviation of the hand.

BONE CYSTS

Bone cysts are stated to be frequent in children under fifteen or eighteen years of age. Latent bone cysts may appear in later adult life. The clinical course of the disease is mild, being disturbed at times by pathologic fracture, which is one of the frequent reasons for bringing the patient under a physician's observation. The lesion occurs in the metaphysis of a long bone, especially in the femur, in which there were 50 cases, and the humerus, with 45 lesions. Bone cysts are rare in the radius, there being only four cases as compared with the above. The

X-ray film reveals a lesion central in the shaft of a long bone, with marked decrease in density. There is a symmetrical contour and a smooth, well-defined outline. Lines of trabeculation may be seen traversing the

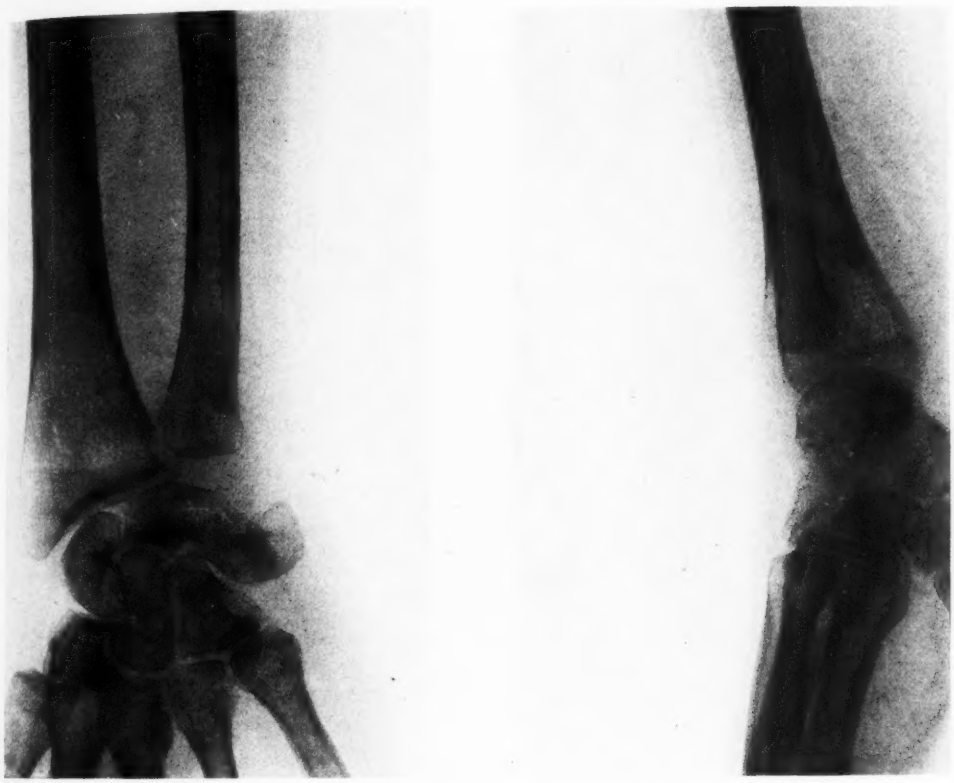


Fig. 3. An early osteolytic sarcoma at the epiphyseal line of the radius.

area of lesser density. Where there has been a pathologic fracture there is a tendency towards ossification. In adults, latent bone cysts are found, but there is much less danger of pathologic fracture. Microscopically, the sections show a fibrous tissue wall with or without giant cells.

In the lower end of the radius there were three cases—one, a girl aged twelve, whose X-ray film showed central expansion of bone, with fracture. Another, aged twenty-six, who had had a tumor for ten years and whose X-ray film showed cystic expansion of bone, had few or no symptoms. The last was a woman of forty-five, who, two years previously, had had a tumor and fracture and whose X-ray examination now shows an ossifying bone cyst. These cases show admirably the age limits, the mildness of symptoms, and the clinical course of the disease. This group is remarkable also for the fact that two of the cases were brought to the physician because of pathologic fracture. All of these cases showed central expansion of bone on the X-ray film. The percentage of bone cysts in this series of lesions of the lower radius is 6 per cent. Results

were good, with 100 per cent cures. The treatment of bone cysts is simply the removal of the connective tissue lining and the obliteration of the cavity with bone chips.

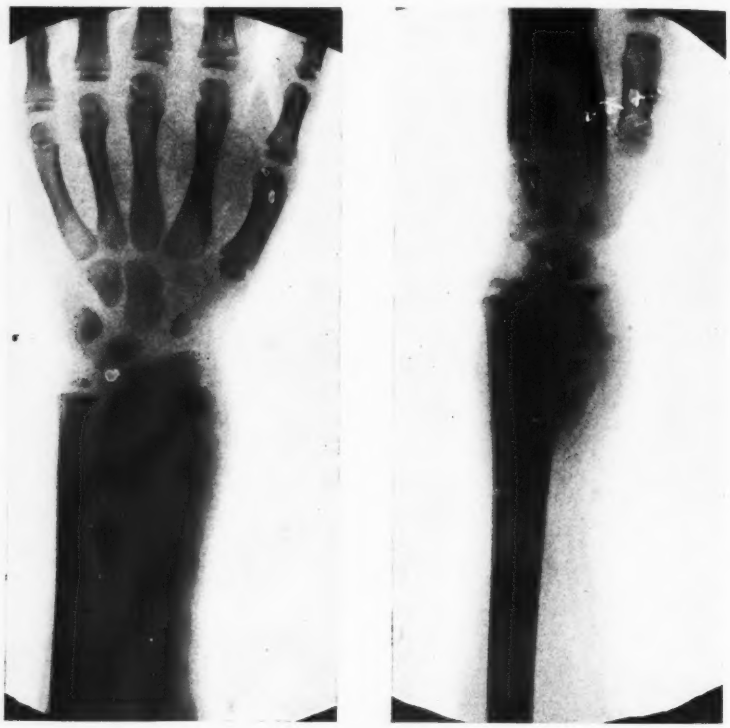


Fig. 4. A sclerosing osteogenic sarcoma in the metaphysis of the lower radius. Marked sclerosis and radiating spicules of new bone are present.

GIANT-CELL TUMOR

In adults, usually above the age of twenty, occurring in the epiphyses of the long bones, there is a group of cases which makes up the greater number of the lesions in the lower end of the radius. In the X-ray examination they show central expansion of the cortical bone similar to that of the bone cysts, though in these lesions the contour is asymmetrical. These cases, too, are frequently brought to the physician's attention because of pathologic fracture. This is a progressive lesion and frequently perforates its capsule. If this occurs, the chances of a cure are diminished because of the difficulty of complete removal. The microscopic picture varies, resembling in some cases that of a bone cyst, with the exception that the giant cells are more prevalent usually and the stroma is made up of small round cells rather than the spindle cells which sometimes predominate in the picture of the bone cyst. The treatment of this type of lesion consists of curettement along with thermal or chemical cauterization.

The lower radius ranks first as the most common position for the giant-cell tumor, followed closely by the lower femur and the upper tibia. Out of a total of 226 cases, 35 were in the lower radius—over 15 per

cent of the total number of cases. Of the tumors of the lower radius, the giant-cell tumors made up 70 per cent. Nine of the 35 cases recurred following curettement. Thirty cases were well following treatment, including those with two or more curettages. In four instances follow-up results could not be obtained. Many of these patients have been well for as long as twenty years and have useful function of the arm and hand. In this group, then, 26 per cent of the cases were recurrent ofter the first operation. The percentage of cures in this entire group of giant-cell tumors is 85 per cent. Recurrences are met with in about 15 per cent of the cases.

SARCOMA

(a) Osteogenic osteolytic sarcoma.—In this type of tumor the position is at the epiphyseal line. The X-ray film shows a mottled area of bone destruction, central in appearance, with or without bone expansion. Microscopically, at the margin there are found giant cells, as in the malignant giant-cell tumor, but in reality it is a form of osteogenic sarcoma with giant cells—a destructive type. In our group there was only one case of this tumor, and death occurred the same year, following amputation, which had been preceded by X-ray treatment.

(b) Ewing's tumor.—Ewing's tumor rarely involves the epiphysis unless it is secondary. The clinical picture may aid in the diagnosis here, as fever and leukocytosis usually occur in the complex of symptoms. The X-ray film shows a widened shaft of bone. The laying down of parallel layers of bone in the so-called "onion-peel" fashion is typical. Microscopically, this tumor is composed of small round cells, with a dense nuclear staining and little cytoplasm. Postoperative X-ray treatment following amputation resulted in death one year later in the only case in this group. The percentage of cures in this general group is approximately 10 per cent.

(c) Chondromyxosarcoma. — Only one case of this type was found in the radius. Because of the fuzzy, infiltrating shadow in the central position in the X-ray film, the lesion was regarded as secondary to a preexisting chondroma or chondromyxoma. The usual age limits of the secondary tumor are from thirty to fifty years. The histological picture is that of a spindle-cell sarcoma mingled with premature cartilage cells and the typical stellate cells of a myxoma. Exploration was done in this case and was followed by curettage. X-ray treatment and toxins were given post-operatively. This patient died shortly after the operation.

(d) Sclerosing sarcoma.—Sclerosing sarcoma occurred once in the lower radius. X-ray examination in this type of tumor shows dense radiating new bone in the metaphyses of the long bones, proliferating from the subperiosteal region, raising the periosteum and extending inward toward the marrow cavity. Microscopically, the tumor shows many osteoblasts and much osteoid tissue. The treatment here, as in the other sarcomas, is excision, resection, or amputation, preceded and followed by X-ray treatment. There is very little evidence that the sclerosing tumor is radiosensitive. The value of X-ray therapy is doubtful. Excision and resection in the above case was followed by death in seven months. Thirty-one per cent of the cases of this general group were five-year cures following amputation.

DIFFERENTIAL DIAGNOSIS

Differentiation must first be made between the central and periosteal groups. In Table I the periosteal lesions are exostosis and sclerosing sarcoma. At times also non-suppurating osteomyelitis presents itself as a periosteal lesion. There is little difficulty in the diagnosis of the benign exostosis. The X-ray appearance is distinctive and typical, showing a uniform protuberance of normal bone. The difficulty arises in the differentia-

tion between osteomyelitis and sclerosing sarcoma. In osteomyelitis, there is both osteoporosis and osteogenesis, without the radiating new bone seen in sarcoma. A history of long duration of the disease and the multiplicity of lesions should lead to the diagnosis of osteomyelitis. When there is difficulty, irradiation may be tried—response to this may make the diagnosis. When there is no response to X-ray treatment and no focus of infection can be found, exploration is done, provided the tumor is operable—if malignant. Frozen sections will make the diagnosis.

Chondromas, bone cysts, and giant-cell tumors present central areas of rarefaction. Contour, position of the tumor, and age incidence enable one to distinguish between bone cysts and giant-cell tumors. Chondroma of the long bones is rare and at times cannot be differentiated. The operative procedure is the same for all central tumors —complete removal and cauterization.

The sarcomas may be differentiated by the irregular outlines seen on the X-ray film. The position of the tumor may aid. In the osteolytic type, which shows a mottled, fuzzy picture, the tumor is found at the epiphyseal line. Chondromyxosarcoma may present a similar picture, but there is more irregular bone destruction in the osteolytic sarcoma. Ewing's tumor is found in the shaft unless it is secondary. A clinical history of fever and leukocytosis, with the laying down of bone in "onion-peel" fashion, is characteristic. Sclerosing sarcoma has been considered in the differentiation of periosteal lesions.

SUMMARY

Fifty lesions of the lower radius have been studied. Nine different types of lesions were found.

The giant-cell tumor predominated, occurring in 70 per cent of the lesions.

Cases are discussed under each group and the results given.

Excellent results were obtained in all of the benign lesions.

Results in the giant-cell tumor group were low on account of the advanced state of the disease. Seventy-four per cent of these cases were cured after the first treatment.

All cases of non-suppurating osteomyelitis, exostosis, chondroma, and bone cysts are well following observation and treatment.

All cases of sarcoma resulted in death.

The differential diagnosis is discussed.

TUMORS OF THE SMALL INTESTINE

THEIR DIAGNOSIS, WITH SPECIAL REFERENCE TO THE X-RAY APPEARANCE

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I.—INTRODUCTION

TUMORS of the small bowel are conceded by pathologists and surgeons to be of extremely rare occurrence. So infrequent are they, in fact, that the occurrence of two cases on the wards of the Johns Hopkins Hospital during the past year has prompted a survey and study of all tumors occurring in this location in the history of the clinic. This paper deals with the clinical aspects of such tumors, with special reference to the roentgenologic findings. A complete *résumé* of the subject, with a detailed report of all tumors found, is to be published later.

The records of this hospital yielded 82 cases of primary tumors located between the pylorus and the ileocecal junction. This comprised 6.5 per cent of all tumors of the gastro-intestinal tract, agreeing roughly with statistics of other writers on the subject. Of this number, 32 (or 40 per cent) were malignant and 50 (or 60 per cent) were benign; 37 per cent gave definite symptoms and were operated upon; 17 per cent gave symptoms but were not operated upon, and the condition was recognized at necropsy; 46 per cent were asymptomatic and were found secondarily at autopsy. The types of tumors found and their locations are shown in the accompanying table.

Only a small percentage of the symptomatic group were diagnosed before operation, the majority being confused with some other intra-abdominal condition. The clinical symptoms and physical findings were most bizarre and very few conformed to a standard picture. Diagnosis, therefore, from the clinical findings alone is at best a hazardous guess. Of the 42 symptomatic cases, the mechanical condition brought about by the tumor was recognized in 14. In six of these the tumor was diagnosed as the cause of symptoms; in eight of the 14, the roentgenogram was responsible for the diagnosis.

X-ray findings are by no means as helpful in lesions of the small intestine as in other parts of the gastro-intestinal tract. There are, however, some cases in which the X-ray plates following an opaque meal are of extreme value, and clinicians are realizing more and more the value of a thorough X-ray examination in obscure cases of gastro-intestinal disorders. Recent publications by Golden (1), Soper (2), and Ritvo (3) have done much to clarify the evaluation of this means of examination. One cannot be justified in considering the X-ray findings as infallible. Negative findings do not exclude a lesion. Positive findings, confirmed by repetition, while revealing the mechanical nature of the disturbance, seldom allow the diagnosis of the nature of the tumor. Careful and intelligent correlation of clinical findings with the X-ray examination may, however, aid materially in establishing the diagnosis before operation.

The technic of X-ray examination of the small bowel must be considered in detail. A flat plate of the abdomen is essential for comparison with the other plates of the series, as well as to reveal the presence of large, dense, intra-abdominal masses. The barium meal is administered following the flat plate. All plates should be taken with the patient standing. The time for the first plate may well be placed at one-half hour following the ingestion of the barium. This

TABLE I.—CLASSIFICATION AND LOCATION OF TUMORS OF THE SMALL INTESTINE

	Type	Location undetermined	Duodenum	Jejunum	Ileum	Totals
Malignant	Carcinomas	2	7	5	6	20
	Sarcomas	1	1	2	10	14
Benign	Chronic inflammatory tumors	1	0	0	5	6
	Adenomas	2	6	1	10	19
	Fibromas	0	0	2	2	4
	Lipomas	0	2	1	3	6
	Myomas	0	0	2	1	3
	Hemangiomas	0	0	1	1	2
	Pancreatic rests	0	1	0	1	2
	Hematomas	1	0	0	1	2
	Argentaffine tumors	0	0	0	3	3
	Cysts	0	1	0	0	1
	Total	7	18	14	43	82

allows the opaque material time to reach and fill the duodenum, which should show best at this time. The following plates should be made at intervals to suit the time of passage of the barium through the intestinal tract: four and eight hours are the intervals of choice, followed by a 24-hour plate on the succeeding day. A barium enema should be given last. This is essential, to rule out involvement of the large intestine and to depict certain tumors near the ileocecal junction which press upon the cecum and cause a filling defect.

The films are developed and read as usual. If there is a lesion visible in one plate of the series, but in one plate only, the series should be repeated for confirmation. Slightly over-exposed plates show filling defects more clearly, and for this reason should be used in the majority of cases.

II.—PATHOLOGY

A brief consideration of the pathology of this group of tumors is pertinent here, especially in reference to their gross characteristics.

Carcinomas lead in frequency of occurrence, closely followed by adenomas and sarcomas, in the order named. Lipomas, tumors of the chronic inflammatory group, fibromas, myomas, and tumors of the carcinoid type follow in order of frequency. Those of a rarer type include hemangiomas, hematomas, pancreatic rests, cysts, and endotheliomas.

GROSS.—The tumors may be roughly divided into two groups based on their gross pathology: those forming constricting annular growths, and those originating on one side of the wall of the intestine and remain-

ing fairly well localized at the point of origin.

(A) Annular tumors.—Most of this group is comprised of malignant growths, carcinomas predominating. Sarcomas also tend to produce a circular growth, but their tendency is more toward an expansive growth involving the mesenteric glands and extending lengthwise along the intestinal wall. The so-called "garden hose intestine" of MacCallum is produced by sarcomatous infiltration of the lower ileum. There were no examples of this form in this group of tumors. Certain benign tumors, namely, those classified as chronic inflammatory by Liu (4), sometimes produce a constricting growth, although the differentiation between these and certain lymphosarcomas is still a moot point. This may possibly be helpful in differential diagnosis, but too few cases have been seen as yet to allow one to judge its diagnostic significance.

(B) Asymmetric tumors.—The majority of tumors of the small intestine fall under this morphologic classification, but this term includes those tumors which arise from the wall and grow either inwardly or outwardly without encircling the gut. A further subdivision into internal and external may be made, based on whether the tumors grow toward or away from the lumen of the gut.

(1) Internal.—The benign tumors such as myomas, fibromas, lipomas, etc., usually grow in the direction of the lumen, probably for the reason that the mucosa and submucosa offer less resistance to growth than the muscularis and serosa. These tumors vary in size from that of a pinhead to that of a hen's egg (seldom larger than the latter) before symptoms of obstruction indicate surgical intervention. Tumors growing internally may be pedunculated or sessile. The former group is comprised almost entirely of adenomas and lipomas, which are usually papillary outgrowths attached to the inner wall by a pedicle varying in size from a slender stalk to a thick cord a centimeter or more in diameter and in length from a few millimeters to three or four centimeters. Sessile tumors are attached to the wall by a broad flat base and are covered loosely by intact mucous membrane unless eroded by pressure necrosis.

(2) External.—This type of tumor is less frequently found than the internal type; as a rule, this type is malignant rather than benign. The tumor grows outward by extension, either free, into the peritoneal cavity, or along the mesentery, involving the mesenteric glands. These are the tumors which attain the largest size, some becoming as large as a child's head before general malaise urges the rapidly declining patient to seek medical relief for the easily perceptible mass in the abdomen. Examination of the specimen may show it to lie loosely in the abdominal cavity attached to the intestine at a single point, or, as in the case of more malignant tumors, surrounding viscera may be caught and involved in the extensive growth.

MICROSCOPIC.—The histological picture of these tumors is very similar to the same types of tumors elsewhere in the body, and as a rule they are easily recognized. Malignant epithelial tumors usually arise from the epithelium of the intestinal glands and are classified as adenocarcinomas. Sarcomas occur quite frequently, practically always in the lower part of the ileum, and are usually of lymphocytic origin. They resemble closely the tumors of the chronic inflammatory group and in the majority of cases it is impossible to differentiate the two from the histological picture. Other types of sarcoma are rarely, if ever, seen.

There is a type of tumor which seems to be limited to the gastro-intestinal tract, histologically resembling carcinoma but clinically benign. This is the so-called carcinoid or argentaffine tumors. The former term is more inclusive, comprising all tumors resembling carcinomas. The latter term is

confined to those which take the silver stain, supposedly because of their origin from cells of the sympathetic nervous system. These tumors most frequently occur in the appendix but are also found in the small intestine. The work of Forbus (5) has done much to elucidate this class of tumors.

Adenomas comprise a large percentage of the tumors found in this series. They arise from the epithelium of the intestinal glands and are, strictly speaking, glandular hyperplasia. A few instances are known of adenomas undergoing malignant change, although this is quite rare. Myomas are more frequently encountered than the figures of this series would lead one to believe. There is nothing unusual about these myomas microscopically, except the enormous number of red blood cells found near the periphery. Intestinal myomas show a striking tendency to bleed, and evidence of this is easily recognized in the section.

The other tumors met with are fibromas, lipomas, hemangiomas, etc., all very similar in microscopic structure to those of the same class occurring in other parts of the body, and offer no diagnostic difficulties when studied histologically.

III.—CLINICAL ASPECTS

Clinical symptoms are dependent largely upon the mechanical condition in the bowel brought about by the tumor, which, in turn, depends upon the size of the growth and its location. The tumors are divided, for convenience, into two classes, those located in the duodenum and those in the jejuno-ileum. Those in the duodenum may produce symptoms by causing obstruction or, as in the case of malignant tumors, by involvement of the surrounding viscera and by cachexia. The same is true to a much lesser extent in the jejuno-ileum. Most tumors in this location cause symptoms by obstruction, complete or partial. Intussusception occurs with sufficient frequency to warrant its consideration as a clinical entity. These tumors are thus classified as those causing obstruction (first, by intussusception, and, second, by pressure or gradual occlusion) and those causing constitutional symptoms.

DUODENUM *(benign).*—This group is comprised chiefly of adenomas, myomas, and fibromas. Invagination seldom occurs, and symptoms are brought on by encroachment of the tumor mass upon the lumen, giving rise to a slowly developing obstruction.

Symptoms: (a) Pain.—The pain is usually felt in the epigastrium, in some cases more distinctly localized in the right upper quadrant, simulating acute gall-bladder disease. It may or may not be preceded by fullness and discomfort, depending upon the presence and degree of obstruction. It may simulate the pain and burning of a duodenal ulcer when the mucosa is eroded, and occur with greatest intensity two to three hours after meals. In cases of chronic obstruction the attacks may be separated by intervals of complete relief.

(b) Nausea and vomiting.—These symptoms precede the onset of pain for from two to five weeks. The vomiting is more pronounced as the obstruction increases. With complete obstruction there is copious watery regurgitation containing particles of undigested food, perhaps bile stained, if the obstruction is below the ampulla of Vater. Dehydration, toxemia and alkalosis, and rapid intense prostration are symptoms secondary to the vomiting and may reach a marked degree. Hematemesis may be present when the tumor has ulcerated, or, according to Goldschmidt (6), in the case of myomas which have a marked tendency to bleed.

(c) Distention.—This is one of the frequent and distressing complaints of duodenal obstruction. At first the patient may feel only a sensation of fullness but this later becomes oppressive, and interferes

with respiration, giving the sensation of a constricting band around the lower chest.

(d) Malaise.—This is a secondary symptom and may be marked in cases of severe vomiting and dehydration. If hemorrhage has occurred, the symptom is brought on by secondary anemia.

(e) Loss of weight.—This is secondary to vomiting and does not reach the severe degree seen in cases of malignancy.

(f) Diarrhea.—This is usually present but not marked, and may alternate with constipation.

(g) Melena.—The patient frequently gives a history of blood-streaked or tarry stools in cases in which the hemorrhage from the tumor has been moderate or severe. Loss of blood through the bowel may in some cases be so great as to endanger life.

Physical signs: (a) Tenderness.—This is diffuse as a rule, but may be more intense in the right upper quadrant. It is seldom exquisite and no rigidity is felt.

(b) Palpation.—The tumor may be felt in the epigastrium, if it is of sufficient size. Benign tumors are usually loosely attached and are movable.

(c) Distention.—This is a marked feature when the obstruction is complete and may be caused largely by a dilated stomach rather than a dilated duodenum. The percussion note is tympanitic.

(d) Succussion splash.—This is a valuable sign, when present. It consists of the sound of a splash of fluid, elicited by shaking the body sharply from side to side. It occurs, however, only when there is air present in the fluid. This is one of the most constant signs of gastroduodenal dilatation.

(e) Temperature, pulse, and respiration.—These may or may not be slightly elevated as a secondary result of the vomiting and dehydration.

(f) Blood picture.—The red cell count and hemoglobin may be low, sometimes no more than half of the normal value. Extremely low counts are suggestive of malignancy or myomas. The white cell count is not markedly affected but may be slightly elevated when the tumor is necrotic.

(g) Stools.—Gross hemorrhage from the duodeum gives the stool a tarry appearance. Smaller traces may be detected by microscopic and chemical examination.

(h) Vomitus.—This is thin, watery, and of low specific gravity. It contains particles of undigested food—all that the patient has eaten if the obstruction is complete. If the obstruction is below the entrance of the common duct, the fluid is bile-tinged. The acid content may be high.

(i) Peristaltic waves.—These are commonly seen in an emaciated individual when the stomach is grossly dilated.

Duodenum *(malignant).*—When obstruction, either partial or complete, is present in malignancy of the duodenum, the symptoms are practically the same as with benign tumors, with the addition of the general symptomatology of malignancy such as cachexia, loss of weight, anemia, absence of free hydrochloric acid, etc. Without obstruction, certain features which are fairly characteristic present themselves.

It has always been customary in describing lesions of the duodenum to divide the structure into three portions. The first and third portions may be considered together, since the symptoms are so nearly the same. The second, or peri-ampullary, portion is considered separately and presents certain interesting clinical features.

Symptoms of the first and third portions. (a) Pain.—The pain is dull and dragging. It is usually constant and bears no relation to meals, but may be paroxysmal. It is seldom referred, but is diffuse in the epigastrium and may be more intense in the right upper quadrant.

(b) Nausea and vomiting.—Nausea is a common feature but follows the pain as a late complication. Vomiting is infrequent,

small in amount, and has a flat taste. Often the patient will compare it to a "hard-boiled egg," signifying an absence of free hydrochloric acid. Hematemesis is more common with malignant than with benign tumors, and is frequently seen when erosion has occurred.

(c) Loss of weight, and cachexia.—These are marked with malignant tumors as in any part of the gastro-intestinal tract. Frequently the weakness and loss of weight are the first symptoms noticed.

(d) Constipation and diarrhea.—Constipation is the general rule but profuse diarrhea was a complaint in several cases.

(e) Melena.—The patient frequently gives a history of passing blood in his stools, or of tarry stools. This is caused whenever a tumor erodes the bowel wall sufficiently to produce a gross hemorrhage.

Physical signs of first and third portions: (a) Tenderness.—This may be exquisite but is more frequently a soreness, most intense over the tumor mass. It may or may not be accompanied by local rigidity.

(b) Palpation.—When the tumor is large enough, a definite mass may be felt. It is commonly fixed by involvement of the surrounding tissues and imparts a sense of resistance to the palpating hand.

(c) Ascites.—Fluid may be demonstrated in the abdominal cavity when the growth has extended sufficiently to cause portal obstruction. This usually signifies metastases.

(d) Gastric analysis.—Chemical examination commonly reveals low or absent free hydrochloric acid.

(e) Stools.—Blood is usually demonstrated in the stools either by gross or chemical examination.

(f) Blood picture.—A profound secondary anemia is sometimes seen in advanced stages. The while cell count is moderately elevated, but may be quite markedly elevated if the tumor has been secondarily infected.

(g) Temperature, pulse, and respiration.—There is nothing remarkable about these values unless moderately elevated as a secondary result of the anemia and cachexia.

Symptoms and signs of the second and peri-ampullary portion.—The symptoms and signs of malignant tumors in this region, which usually involves the ampulla of Vater, are similar in general to those of tumors in the first and third parts. There are, however, the following additional features:

(a) Pain.—This may be more acute and be centered near the mid-line. It occurs when the growth has caused an occlusion of the mouth of the ampulla and bile is forced by back-pressure into the pancreatic ducts, setting up a chemical irritation of that organ. Fatty necrosis may be a later complication from stasis of the pancreatic secretions.

(b) Jaundice.—This usually appears early and is painless. It may be the first symptom, progressing rapidly without remission. It is accompanied by intense itching.

(c) Stools.—The feces are clay-colored when the ampulla is completely blocked. Chemical test shows absence of bile pigments.

Carcinoma of the ampulla is practically impossible to distinguish from carcinoma of the head of the pancreas. It is rapidly progressive and terminates in early death in nearly every instance.

Diagnosis of duodenal tumors: (1) Carcinoma of the pylorus.—This may simulate closely an obstructive malignancy of the duodenum, but the symptoms come more gradually in the former.

(2) Duodenal ulcer.—This may be a source of confusion in certain cases. Carcinoma of the duodenum, however, causes

an absence of free hydrochloric acid in the stomach contents, is more acute than duodenal ulcer, has not the same periodicity, and the pain is less sharp.

(3) Tumor of the pylorus herniating into the duodenum rarely simulates a duodenal tumor and sometimes can be distinguished by X-ray examination, but usually the condition is not recognized until operation.

(4) Carcinoma of the head of the pancreas.—This is practically indistinguishable from carcinoma arising in the ampulla of Vater, except at the operating table.

(5) Angiomesenteric ileus.—Acute dilatation of the duodenum brought about by occlusion caused by traction from the superior mesenteric vessel is more acute in onset than in symptoms: it is usually postoperative, and may be relieved by placing the patient in the Trendelenburg position.

(6) Chronic duodenal dilatation by constricting bands of adhesions is difficult to distinguish from dilatation due to a benign tumor. Frequently there is a history of upper abdominal disturbances or surgical interference.

(7) Acute gall-bladder disease may sometimes be considered when the pain is localized in the right upper quadrant. The absence of other biliary symptoms should make the diagnosis clear.

TUMORS OF THE JEJUNO-ILEUM.—Obstruction is by far the most common result of a tumor in this part of the intestine. Symptoms, therefore, should be referable to that condition. There are a few tumors, however, mainly malignant ones, which do not cause obstruction and produce symptoms only through their systemic effects. These are quite obscure and present a most difficult problem of diagnosis. "Obstructive and Non-obstructive Tumors" is a convenient classification, therefore, from the standpoint of symptomatology.

(A) Obstructive tumors. — Obstruction may be brought about by intussusception and by encroachment of the tumor upon the lumen. These tumors deserve separate consideration in that certain features are widely different.

(1) Intussusception. — Intussusception occurs in 30 per cent of the tumors found in the jejunum and ileum, according to Staemmler (7). The figures for this group were slightly less, namely, 23 per cent. The condition was found to occur only one-third as frequently as in malignant tumors.

This type of intussusception differs from that found in children. It is spontaneous and thought to be caused by a hyperactive gut. In these patients, the explanation commonly assumed is the gripping of a tumor, usually pedicled, by the peristaltic waves, by which a section of the gut is telescoped bodily inside of a section lower down, the tumor always remaining at the apex of the intussuscepted piece of bowel. Spontaneous reduction is much less common than in the acute intussusception of children, although it does occur. It may later recur and become chronic, marked by periods of almost complete relief from symptoms.

Symptoms: (a) Pain.—The onset of intussusception is marked by a sudden, sharp, agonizing pain, which does not begin to abate until some hours later. It is fairly well localized, usually in one or the other lower quadrant, most frequently the left. If the intussusception is reduced spontaneously, the pain ceases immediately. This is not likely to occur after the first twelve hours, as adhesions will have formed between the serous surfaces of the gut wall, and surgical intervention will be indicated. The symptoms may abate after awhile, only to recur again and again.

(b) Vomiting.—This is one of the first symptoms, following shortly after the onset of pain. It is occasionally repeated, but seldom becomes stercoraceous or retching.

(c) Stools.—The bowels below the obstruction become emptied after a time. Soon after, tenesmus begins and small amounts of bloody mucus are passed at frequent intervals, arising from the squeezed and constricted portion of the intussusceptum. No further free bowel movements occur after the condition is well established.

(d) Shock.—This does not develop at first but in all probability will be established by the time the clinician reaches the patient.

(e) Distention.—This develops after a few hours and is not so marked as in other types of intestinal obstruction. In some cases it is absent altogether, while in others it may be a marked and distressing symptom.

(f) Mass in abdomen.—Frequently the patient may state that he has felt a mass develop in one of the lower quadrants, some hours after the onset of pain and vomiting, and when the abatement of the latter symptoms have given him a sense of false security.

Physical signs: (a) Palpation.—The abdomen is slightly distended but not markedly tympanitic. In extreme cases peristaltic waves may be seen. Tenderness is not a marked feature. Palpation of a mass is fairly constant: it is caused by the telescoped bowel and is more easily palpable as the condition progresses. It is sausage-shaped and hard and rigid during the attacks of pain; most commonly located in one of the lower quadrants but occasionally it may be felt in the region of the transverse colon. It is slightly tender but not exquisitely so, and may change in size and position from day to day as the intussusception progresses.

(b) Appearance.—The patient may reach a state of shock late in the course of the attack. The skin will be cold, clammy, and pallid and the patient apathetic. If the condition is chronic and of long standing, the patient may be emaciated.

(c) Temperature, pulse, and respiration.—These data are especially valuable in determining the presence of shock. If shock is present, the pulse will be rapid, thready, and of poor volume. Respirations will be rapid and shallow. The temperature is usually subnormal.

(d) Blood examination.—The red cells and hemoglobin usually indicate a moderate degree of secondary anemia. The leukocyte count is moderately elevated.

(e) Stools.—Blood and mucus in small amounts comprise the bowel movements. The former is easily detected in the gross and is a nearly constant finding.

(f) Vomitus—Vomiting is not copious and the fluid is thick and bile-stained. Occasionally it is stercoraceous, if the intussusception is low in the intestinal tract.

(2) Encroachment upon the lumen.—This may occur by constriction of the lumen by a malignant growth encircling the gut, by an internal tumor protruding gradually into the lumen, or by pressure from the outside by a neoplasm of the external form. Malignant tumors usually cause symptoms by constriction or pressure: benign, more frequently by protrusion and filling of the lumen—the mode of production is mechanically different, but the result and symptoms are essentially the same. The rapidity of growth is naturally more marked in malignant tumors, and the patient shows the characteristic systemic features of a malignancy.

Symptoms.—The mode of onset is much more gradual than is the case with intussusception. The patient may feel "below par" for a number of months before symptoms of actual obstruction set in.

(a) Pain.—The pain is commonly diffuse in the lower abdomen, but may sometimes be confined to one or the other lower quadrant. In a few cases, the diagnosis of appendicitis was made. In still other cases, pain localized about the umbilicus. It is most frequently dull and aching; at other

times, sharp and cramp-like. In any event, there is a slow increase in the intensity of the pain, with few or no remissions.

(b) Distention.—This is not a characteristic feature in all the cases, but the patient often complains of a bloating sensation after meals. Rarely does it become significant until obstruction is complete.

(c) Nausea and vomiting.—These symptoms are not marked, but fairly constant. They appear late, the nausea preceding the vomiting. The patient believes that eating is responsible, and attributes the upset to his "run-down condition." Vomiting recurs at intervals of a week or two, but is more frequent and serious when no obstruction is located high in the jejunum.

(d) Malaise.—Always more marked in malignant tumors, this is the first symptom noticed by the patient. He feels "run down," tires easily, and is generally "below par." Anorexia may become marked, and, if the patient does not force himself to eat, a serious and progressive loss of weight may ensue.

(e) Stools.—Constipation is commonly marked and may have been present for a number of years. Blood, either gross or microscopic, may be present, and is more apt to appear in cases of myomas and ulcerating malignant growths.

(f) Mass.—If the tumor is large enough, the patient may complain of a mass which he has felt increasing gradually in size for some time. Malignant tumors are more apt to be noticed subjectively, as their growth is more rapid and more apparent.

Physical signs: (a) General appearance.—When the physician is consulted, the picture is that of a chronic partial obstruction. The patient is a cachectic individual, under-weight and under-nourished. He is pale, especially in malignant conditions, and emaciated in extreme cases.

(b) Tenderness.—There may be slight tenderness over the tumor mass in some cases, but it is seldom widespread or exquisite.

(c) Palpation.—A mass is felt if the tumor has attained sufficient size; in other cases, an indefinite sense of resistance is encountered. Voluntary muscle spasm is occasionally present but no actual rigidity.

(d) Distention and tympanites.—A slight fullness may be noted in the earlier stages of obstruction, but marked distention does not appear until the obstruction is complete.

(e) Blood picture.—A secondary anemia is the rule with malignant tumors, less constant with benign. It may reach a severe degree if there has been profuse hemorrhage from the bowel—even to the point of endangering life. The leukocyte count is not constant but tends to be slightly elevated.

(f) Stools.—Blood, either microscopic or gross, may be demonstrated, more constantly in malignant tumors and myomas.

(B) Non-obstructive tumors.—There is a small group of tumors which, by growing away from the lumen of the intestine into a free cavity, do not produce a mechanical obstruction, and consequently the symptoms are dependent entirely upon toxicity and pressure. The clinical picture is most obscure and no hint of the condition is gained until the tumor is large enough to be palpated. The neoplasms of this group are most commonly malignant (carcinomas), although numbers of the chronic inflammatory group of lesions are sometimes found.

Symptoms: Malaise.—This is the first and practically the only symptom noticed by the patient. He tires easily and may become short of breath upon slight exertion. The pulse rate may be slightly irregular, and slight loss of weight and anorexia soon appear. The physician is sought, but nothing that will account for the symptoms is found. The condition progresses steadily until the

tumor becomes large enough to be felt, and then the gravity of the condition is realized.

Signs: Appearance.—The patient looks under-nourished and under-weight. Nothing positive is found until the tumor becomes large enough to impart a sense of resistance to the surrounding tissues. If the case is kept under observation, a mass can sooner or later be distinguished and a laparotomy is indicated. Not until the abdomen is opened is the diagnosis clear, and by that time the tumor, if malignant, has progressed in most instances to the point where it is hopelessly inoperable.

This type of case is the one in which X-ray examination offers the only hope of an early diagnosis. Even then, the chances of such a tumor being visible in a flat plate are few.

Diagnosis of tumors of the jejuno-ileum: (1) Obstruction due to constricting bands and adhesions.—This condition may be exceedingly difficult to distinguish from a true tumor of the small intestine, and the clinician must rely almost entirely upon the history. This usually has to do with some intra-abdominal condition, such as peritoneal irritation or a surgical operation which has led to the formation of adhesions.

(2) Obstruction due to volvulus or strangulation of the gut. The history of onset is indistinguishable from intussusception. The distention and tympanites are less marked in the latter and tenderness is less generalized. The sausage-shaped tumor palpable in intussusception is absent.

(3) Spontaneous intussusception occurs primarily in infants but presents clinical pictures impossible to distinguish from intussusception due to tumors.

(4) Appendicitis.—This diagnosis has been made from the history of onset, together with physical findings, and is especially difficult when the tumor has become necrotic. Symptoms of a tumor are more constant, do not have the long remissions of chronic appendicitis, and the laboratory findings are not ordinarily those of an acute inflammatory process.

(5) Tumors elsewhere in the gastro-intestinal tract.—These constitute probably the source of greatest confusion. Symptoms are referable to the gastro-intestinal tract. X-ray examinations following a barium meal or barium enema are of extreme value in ruling out the stomach and large intestine as seats of the lesion.

IV.—ROENTGENOLOGIC FINDINGS

The small intestine is empirically divided into three sections for the study of X-ray findings. The duodenum, fixed in its entirety, presents fairly constant findings. It should be possible to determine with reasonable accuracy the seat of the lesion, and, to a lesser extent, the type of the lesion. The terminal end of the ileum is relatively fixed to the cecum. Defects appearing in this region offer, therefore, a better opportunity for diagnosis and localization. The remainder of the small intestine, which includes the jejunum and upper part of the ileum, is not fixed and lesions are very difficult to demonstrate. Localization may be facilitated by bearing in mind the normal appearance of the jejunum and ileum following a barium meal. The jejunum is visualized mainly on the left of the mid-line. It is normally about 4 cm. in diameter and has a lacy, mottled appearance due to the valvulæ conniventes. The ileum being smaller, the barium gives a more dense shadow and tends to show on the right of the mid-line, lower than the jejunum. Demonstration is thereby facilitated, but diagnosis, at best, is little more than shrewd guessing.

Duodenum: (1) Dilatation.—This is the easiest type of lesion to recognize, seen in cases in which the tumor has caused an obstruction, either by a polypoid tumor encroaching upon the lumen or by a constricting malignant growth, but seldom by intus-

susception. In either event, there is dilatation of the duodenum above that point, greater when the obstruction is complete. This shows in the X-ray film after a barium meal as a large dense shadow following the general contour and direction of the duodenum to the point of obstruction. Finger-like projections of the barium shadow may also be seen in the dilated crypts of Lieberkühn. One is justified, in such a case, in diagnosing obstruction, which in the majority of cases is due to a tumor. If the obstruction occurs in the third portion of the duodenum, however, it is apt to be confused with gastromesenteric ileus. Six-hour gastric retention as shown in the gastro-intestinal series is, according to Golden (1), strongly indicative of a duodenal tumor.

(2) Filling defect.—Carcinomas which are early and have produced an erosion in the duodenal wall give a picture strongly resembling that of duodenal ulcer. The similarity may be so great that it is impossible to distinguish between the two, and one is forced to rely upon clinical data, the history of onset, and gastric acidity. The defect is usually a small irregular crater and may occur in any part of the duodenum. Quite frequently found in the region of the ampulla, it is valuable in differentiating early carcinoma of the ampulla from carcinoma of the head of the pancreas.

(3) Encroachment upon the lumen.—Constricting malignant growths are sometimes seen in the X-ray film as indentations upon the barium shadow from both sides. In the earlier stages this may not be marked, and there may be no dilatation. As the constriction continues and obstruction increases, dilatation begins to appear, and a large shadow is seen proximal to the growth, with a tiny thread of barium trickling through.

A solitary tumor nodule developing in the wall of the duodenum may be revealed as an indentation in the barium shadow, if it is of sufficient size. It is impossible in this case, however, to say whether the tumor is benign or malignant. In the constricting form, the evidence is in favor of malignancy. There is occasionally seen a decrease in the density of the barium shadow which is not a true indentation, and one receives the impression that the tumor causing it is not continuous with the wall but is floating loose in the lumen. These are usually papillomas at the end of a pedicle; when observed by the fluoroscope they may be seen to change position. On rare occasions bits of barium may be seen to stick in the crevices of the papilloma after the rest of the barium meal has passed on through the duodenum.

Jejunum and proximal ileum.—This is the part of the small intestine which is movable, and, while it conforms to the general divisions described by Mall (8), it is extremely difficult to locate a lesion by X-ray examination.

(1) Dilatation.—This is the type of lesion most frequently seen. It is caused by an obstruction and may be found anywhere in the cavity occupied by the intestines. A considerable length of intestine may be dilated, and, following the barium meal, the shadow may appear in large, dense, irregular coils. As the barium settles, the shadow will be shorter and bulbous, ending at the point of obstruction; or, if the obstruction is not complete, a thin ribbon of barium may trickle through. Even this may change position with subsequent examinations, unless the growth has fixed it to the abdominal wall.

Very little can be determined regarding the character of the lesion from the X-ray findings, and in those cases which produce no obstruction it is futile to attempt a diagnosis.

(2) Dense shadow.—The tumor will sometimes be visible in a flat plate of the abdomen without a barium meal. It will be seen merely as a large irregular shadow,

visible only when the tumor is large and the consistency dense. This cannot justify a diagnosis alone, since there are many other conditions which may cast the same type of shadow. In conjunction with positive clinical data, however, it gives a valuable lead.

Terminal ileum.—This is the site of predilection for tumors of the chronic inflammatory group and lymphosarcoma. The reason for this is not certain, but the excessive lymphoid tissue in this region, the so-called Peyer's patches, evidently predisposes to this type of tumor.

(1) Dilatation.—Obstruction is the most frequent lesion, causing a dilatation of the gut above the tumor similar in every way to that described in the previous group, except that the shadow is more constantly fixed. The barium meal shows a bulbous dilatation of the ileum down to the point of obstruction. The barium enema discloses a partially collapsed large intestine. The barium flows up to the point of obstruction and then stops. When such a picture is constantly in the right lower quadrant in two or more positions, one is reasonably justified in placing the tumor in the lower ileum.

(2) Filling defect.—Occasional cases may show a slight defect in the lower ileum. This is not constant, but when it does appear and is confirmed by subsequent X-ray examination, it offers a diagnostic point. A more constant finding is an incompletely filled cecum. This may be due to involvement of the cecum or to pressure upon it from the outside by the mass in the ileum. A third condition preventing filling of the cecum is an intussusception of the ileum into the cecum. These findings are not infallible; it is seldom possible to decide the site of the original growth, whether primary in the cecum or ileum.

(3) Dense shadow.—This finding bears the same significance as when found in the jejuno-ileum. It is caused by a large tumor of dense consistency, and changes position very little, if at all, in repeated films.

(4) Pseudodiverticulum.—Soper (2) has emphasized the appearance of a shadow resembling that produced by a true diverticulum, in large eroded carcinomas. The shadow in the latter is more irregular and frequently a gas bubble is seen at the highest portion of the cavity. However, no cases of this type have been encountered in this series of tumors.

V.—CASE REPORTS

Case I.—E. L. (Fig. 1), a white male, aged 52, came to the hospital complaining of epigastric pain and recurrent vomiting of three months' duration. The symptoms had increased during the past few weeks, and when admitted to the hospital he was vomiting everything eaten and suffering from severe abdominal cramps. Physical examination showed marked tenderness of the epigastrium and visible peristaltic waves. He frequently vomited small amounts of bile-stained fluid. X-ray examination following a barium meal revealed marked dilatation of the duodenum throughout its whole length, and moderate dilatation of the stomach. The seat of obstruction was thought to be near the duodenojejunal junction.

At operation, a firm sessile tumor 9.5 × 4.5 × 3.5 cm., projecting into the lumen and covered by a freely movable intact mucous membrane, was removed from the distal third of the duodenum. Histological examination showed it to be a fibroma, composed of adult fibroblasts.

Recovery was uneventful and the patient was discharged completely well. Sixteen months later he reported for re-examination in excellent health.

Case II.—T. S. (Fig. 2), a white male, aged 68, was admitted to the Union Memorial Hospital complaining of a growing pain in the epigastrium of six weeks' dura-

tion. Six months previously he had first noticed a gradually increasing fullness in the epigastrium. Actual pain began three weeks before admission and was most intense two to three hours after meals. He had lost seven pounds in three months. Physical examination showed a questionable mass in the right upper quadrant which was not tender. X-ray films showed moderate dilatation of the first part of the duodenum, below which there was an area of decreased density in the barium shadow. The diagnosis of benign papilloma of the duodenum was made, and the patient underwent a laparotomy. At operation, a long papillary cauliflower-like tumor was found attached by a thick pedicle on the duodenal side of the pylorus. Microscopical examination showed it to be a typical glandular hyperplasia and in one part of the tumor malignant degeneration had set in.

Following operation, the patient developed signs of peritonitis and died on the fourth day after operation.

Case III.—C. L., a while female, aged 19, came to the hospital complaining of weakness of several years' duration. She had had a "blood tumor" removed from the tongue at the age of seven years. She had been treated for anemia, with little more than temporary improvement. During the past year she had complained of gaseous eructation and constipation. She was a thin, very pale individual. Physical examination was otherwise negative. The blood examination revealed a profound secondary anemia: red blood count was 1,860,000; hemoglobin 19 per cent. Stools were black and strongly positive for blood. X-ray examination showed a suggested filling defect in the second portion of the duodenum. The condition was thought to be due to a tumor of the duodenum in the presence of an obscure anemia, and a blood transfusion was given in preparation for operation.

At operation, a rounded nodule 2 cm. in diameter was found involving the mucosa and submucosa of the second third of the duodenum. The tumor was dark red on section and oozed blood. Microscopic section showed numerous sinuses containing many red cells. Diagnosis, hemangioma duodenum.

Fig. 1. Roentgenogram following barium meal. The stomach and duodenum are enormously dilated and the valvulæ conniventes can be seen plainly. The site of the lesion was placed near the duodenojejunal junction. No actual filling defect can be seen. (Dr. Dean Lewis' case.)

The tumor was excised and the patient's recovery was uncomplicated. Stools were free from blood for several days, but it reappeared and was present at the last report, six weeks after operation, although the general condition of the patient was improved.

Case IV.—E. B., colored male, aged 60, was admitted to the hospital complaining of indigestion, weakness, and anorexia. Symptoms had developed over a period of six months. He had lost a moderate amount of weight. Epigastric pain, intensified by eating, had developed, and he vomited frequently. The vomitus on a few occasions

contained old blood. Constipation was marked.

He was a poorly nourished colored man, somewhat under-weight, and showing moderate pallor of the mucous membranes. The abdomen was distended and active peristaltic waves were seen in the hypogastric and iliac regions. An indefinite sense of resistance was encountered in the epigastrium.

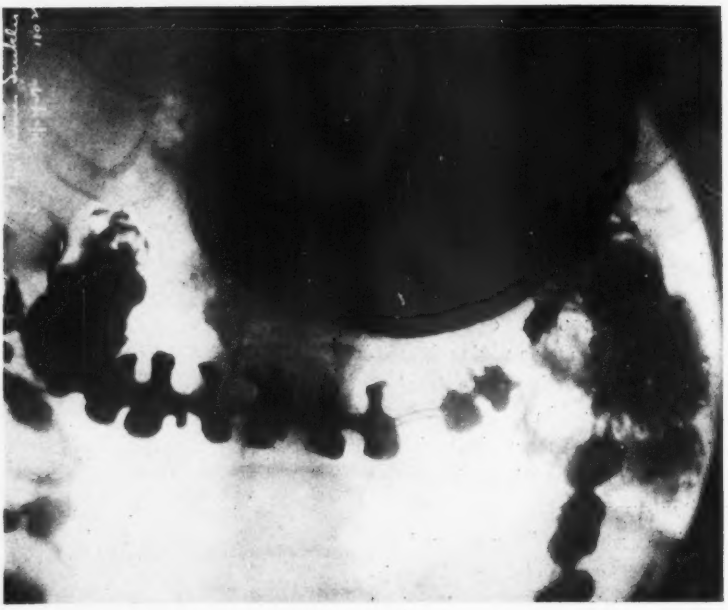

Fig. 2. Roentgenogram following barium meal. The stomach is moderately dilated and there is a bulbous dilatation of the first part of the duodenum, with a decrease in the intensity of the shadow. Distal to this there is an entire absence of barium shadow. A malignant papilloma was removed at operation from the first portion of the duodenum. (Patient of Dr. J. M. T. Finney, Sr. Material for photograph obtained through the courtesy of Dr. Finney and Dr. Charles A. Waters.)

The X-ray film showed enormously dilated coils of small intestine, but the point of obstruction could not be determined. A barium enema showed no defect in the large intestine. The diagnosis of obstruction in the small intestine was made, and exploratory laparotomy advised.

At operation, a constricting tumor the size of an English walnut was found four feet above the ileocecal valve, causing almost complete obstruction. The ileum above the obstruction was tremendously dilated and below it was collapsed. Histological examination showed a dense collection of small round cells, similar to those of the lymphocytic series. The neighboring glands were enlarged, but soft, and showed no sign of malignancy. Diagnosis, chronic inflammatory tumor of the ileum.

Case V.—U. M. (Fig. 3), a white male, aged 69, came to the hospital complaining of indigestion and general malaise. He had felt "below par" for several months. Ten days previously he had noticed some irregularity of his pulse and for the last week he had had moderate indigestion, with intermittent attacks of dull abdominal pain. On physical examination a dense irregular mass the size of a grapefruit was found in

the lower left quadrant. X-ray examination showed moderate dilatation of the loops of the ileum, with evidences of partial obstruction.

Exploratory laparotomy was performed and a large abscess found attached to the ileum. It was evacuated and drained and a communication found between the intestinal lumen and the abscess cavity. Culture from the abscess grew *B. coli*. A piece of tissue was removed for diagnosis. Microscopic section showed small round cells, similar to those of the lymphocytic series, closely packed together, but with the appearance of malignancy. Diagnosis, sarcoma of the ileum.

Fig. 3. Roentgenogram of small intestine and colon following barium meal and barium enema. The large intestine is completely filled. The lowest coil of the ileum can be made out and is moderately dilated in the terminal portion before it passes into an area of constriction just proximal to the ileocecal valve. A tiny, thread-like stream of barium can be seen entering the cecum. (X-ray film obtained through the courtesy of the Union Memorial Hospital.)

The patient developed peritonitis and died five days after the operation.

Case VI.—A. P., colored female, aged 46, came to the hospital complaining of gen-

eral malaise for six months; intermittent, cramp-like, diffuse pains in abdomen; profuse diarrhea for three months; nausea and vomiting for several days, four or five times a day. The patient was anemic and complained of the most intense pain in the right lower quadrant. There was some voluntary rigidity. An irregular, tender mass in the right lower quadrant was felt on rectal examination, external to the rectum and seeming to be fairly well fixed. Red blood count was 3,290,000; hemoglobin 72 per cent; free hydrochloric acid, 0. X-ray examination showed the sigmoid to be pulled to the right and the cecum incompletely filled. The pre-operative impression was that this was a case of intestinal obstruction due to malignancy at the ileocecal junction.

At operation, an annular growth was found constricting the ileum 13 cm. above the valve, but lying against the cecum and compressing it. Resection was done and the ileum anastomosed to the cecum. Microscopic section showed large malignant cells of the epithelial type. Diagnosis, carcinoma of the ileum.

The patient recovered from the operation and was discharged as improved. When last seen, six weeks after the operation, she had a discharging sinus. Further follow-up was impossible as the patient left the city.

Case VII.—C. H., colored male, aged 68, was admitted to the hospital with the complaint of cramp-like pains in the abdomen, anorexia, vomiting, and constipation developing and progressing over a period of six months. He had lost forty pounds in weight. At times he had felt a lump the size of a hen's egg in the right lower quadrant. He was an emaciated old negro man, with distinct pallor of the mucous membranes. A sausage-shaped tumor mass was felt in the right lower quadrant, appearing and disappearing with loud gurgling sounds. Upon rectal examination a small hard mass could be felt outside the rectum, high up on the right. Occasional peristaltic waves could be seen coincident with the attacks of pain. The blood showed a moderate secondary anemia. Stools were negative for blood. There was no free hydrochloric acid in the gastric contents. X-ray examination showed an obstruction at the ileocecal junction which suggested a malignant process. The condition was diagnosed as intestinal obstruction due to a neoplasm of the colon, and a laparotomy was performed. A hard, cartilaginous, annular tumor was found 20 cm. above the ileocecal valve, causing partial obstruction of the lumen. It was resected and a lateral entero-enterostomy performed.

Following operation, the patient developed generalized peritonitis and died two days later.

Microscopic section showed a tumor composed of large malignant epithelial cells. Diagnosis, carcinoma of the ileum.

Case VIII.—G. S., white male, aged 37, came to the hospital complaining of pain in the right side. Eight months before he had felt something give way inside his abdomen following a strain. He began to feel ill, lost weight, became nauseated, and vomited at intervals. He occasionally noticed that his stools were blood-streaked. There was a period of remission during which he was almost entirely free from symptoms, but seven weeks before admission the pain had returned and later he began to vomit frequently and was constipated.

Physical examination showed a pale, emaciated white man. Findings were negative except for a rounded, movable mass in the right lower quadrant, which was tender to pressure. He had a severe secondary anemia, but stools were negative for blood. The X-ray film showed a filling defect a short way above the cecum. It was diagnosed as neoplasm of the ascending colon, and a laparotomy was performed. At operation, a hard, annular, constricting tumor was found encircling the ileum 4 cm. above the

valve. It had intussuscepted into the cecum, producing a partial obstruction, but the overlying mucosa was intact. The cecum and terminal ileum were resected and an ileocolostomy performed. Recovery was uncomplicated and he was discharged as improved. Histologically, the tumor was composed of small round cells densely packed together. They did not have the general appearance of malignancy. Diagnosis, chronic inflammatory tumor.

SUMMARY

Eighty-two tumors, occurring in the small intestine between the pylorus and ileocecal valve, have been found in the records of the Surgical Pathological Laboratory of the Johns Hopkins Hospital. Of this number, 40 per cent were malignant and 60 per cent were benign. Only 51 per cent showed symptoms, the remainder being found at autopsy. Those giving symptoms have been studied in an attempt to classify the tumor according to the symptomatology. It was found that the symptoms produced varied according to the mechanical condition produced in the bowel, which in the majority of cases was obstruction.

Malignant tumors showed the superimposed effect of any gastro-intestinal malignancy, namely, cachexia, loss of weight, and anemia.

Tumors of the duodenum produced symptoms more acutely than lower in the intestine, and were frequently confused with tumors of the stomach and ulcers of the duodenum.

Absence of free hydrochloric acid in the gastric contents in the presence of carcinoma of the small intestine occurs so nearly constantly as to make it an important diagnostic feature.

The presence of occult blood following a meat-free diet is important, and, if repeatedly positive, is of great significance.

X-ray examination offers the best positive means of diagnosis, but it is not infallible. Negative findings do not rule out a lesion; positive findings do not necessarily indicate a tumor. Only when used in conjunction with important clinical data can its worth be evaluated. The X-ray examination should include a flat film of the abdomen and a barium enema, in addition to the regular gastro-intestinal series. The greatest care should be exercised in making and examining the films, and any doubtful finding checked by repeating the examination.

CONCLUSIONS

The symptomatology of tumors of the small intestine is at best an obscure subject. Due to the paucity of material the clinician is unable to compare case reports and formulate a working standard. The rarity of such tumors has discouraged correct diagnoses on some occasions simply by the laws of chance. Not more than half of this group of neoplasms studied in this clinic caused symptoms. These cases, 42 in number, have been studied meticulously with regard to the clinical manifestations and an attempt has been made to provide a working basis for diagnosis.

The findings correspond roughly to those of other gastro-intestinal tumors, especially in the laboratory tests. Localization is the most difficult. The X-ray examination is invaluable in this respect and one should never neglect to do a thorough roentgenologic study of the whole gastro-intestinal tract if the clinical symptoms point to a tumor in this system. Even under these circumstances, the X-ray is not infallible. Lesions seen in the roentgenogram should be compared with the other laboratory findings, especially the finding of occult blood in the stool, and evaluated in respect to these findings.

Emphasis should be placed on a thorough and careful investigation by these means of examination in every case in which the diagnosis is obscure. The correct diagnosis will by no means be made in every case but it should materially aid the surgeon in recognizing the stage of advancement of the lesion, thereby giving the patient the advantage of an early operation, or, if the condition is hopelessly advanced, prevent him from undergoing a useless and discomforting laparotomy.

BIBLIOGRAPHY

(1) Golden, R.: Non-malignant Tumors of the Duodenum: Report of Two Cases. Am. Jour. Roentgenol. and Rad. Ther., November, 1928, XX, 405.

(2) Soper, H. W.: Roentgen-ray Diagnosis of Lesions of the Small Intestine. Am. Jour. Roentgenol. and Rad. Ther., August, 1929, XXII, 107.

(3) Ritvo, M.: Roentgen Diagnosis of Lesions of the Jejunum and Ileum. Am. Jour. Roentgenol. and Rad. Ther., February, 1930, XXIII, 160.

(4) Liu, J. Heng: Tumors of the Small Intestine, with Especial Reference to the Lymphoid Cell Tumors. Arch. Surg., October, 1925, XI, 602.

(5) Forbus, W. D.: Argentaffine Tumors of the Appendix and Small Intestine. Bull. Johns Hopkins Hosp., August, 1925, XXXVII, 130.

(6) Goldschmidt, W.: Bleeding Myoma on the Small Intestine. Deutsche Ztschr. f. Chir., 1923, CLXXVIII, 128.

(7) Reichel, Paul, and Staemmler, Martin: Die Neubildungen des Darmes. Neue Deutsche Chir., Ferdinand Enke, Stuttgart, 1924.

(8) Mall, Franklin P.: Ueber die Entwickelung des menschlichen Darmes und seiner Lage beim Erwachsenen. Arch. f. Anat. u. Entwick. gesch., 1897, p. 403.

(9) Clifton, Harry C., and Landry, Benedict B.: Fibromata of the Intestines: Report of a Case and Review of the Literature. Boston Med. and Surg. Jour., July 7, 1927, CXCVII, 8.

(10) Saint, James H.: Polypi of the Intestine, with Special Reference to the Adenomata. British Jour. Surg., July, 1927, XV, 99.

(11) Key-Aberg, Kurt: Contribution to the Knowledge of Myomata in the Small Intestine. Acta Chir. Scandinavica, 1927, LXII, 261.

(12) Fullerton, Andrew: Sarcoma of the Small Intestine in a Boy of Three Years, Associated with Intussusception of the Ileum. British Jour. Surg., April, 1926, XIII, 754.

(13) King, E. L.: Benign Tumors of the Intestines, with Special Reference to Fibroma: Report of a Case. Surg., Gynec. and Obst., July, 1917, XXV, 54.

(14) Dewis, John W.: A Small Fibroma of the Ileum Resulting in Obstruction of the Bowel, with a Consideration of Various Forms of Benign Intestinal Tumors. Boston Med. and Surg. Jour., Oct. 11, 1906, CLV, 427.

(15) Balfour, D. C., and Henderson, E. F.: Benign Tumors of the Duodenum. Ann. Surg., January, 1929, LXXXIX, 30.

(16) Heurtaux: Note sur les tumeurs, bénignes de l'intestin. Arch. prov. de Chir., 1900, IX, 1.

(17) Plenk, Andreas: Zur Kasuistik und Klinik der Darmmyome (Myomata of the Intestine). Wien. klin. Wchnschr., April 28, 1927, XL, 556.

(18) Smoler, Felix: Ueber Adenome des Dünn- und Dick-Darmes. Beitr. z. klin. Chir., 1902, XXXVI, 139.

(19) Odelberg, Axel: Lipomata of Jejuno-ileum. Acta Chir. Scandinavica, 1920, LIII, 154.

(20) Hellström, Nils: Kasuistische Beiträge zur Kenntnis des Intestinal Lipoms. Deutsche Ztschr. f. Chir., 1906, LXXXIV, 488.

THE REPORT OF FIVE CASES OF SUBACUTE OSTEOMYELITIS OF THE FEMUR RESEMBLING SARCOMA

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WHILE osteomyelitis in the majority of cases is a disease of childhood, there is a slow subacute type which may appear at any age. In this type the process may go on for a long time, the result being an osseous formation quite difficult to differentiate from sarcoma. The causative agent in practically all the cases is an attenuated organism of low virulence, which has been present in the system for a long period of time. The patient gains a certain amount of resistance against this organism, the result being a subacute rather than an acute type of osteomyelitis.

Fig. 1-*A*. Case 1. Roentgenogram showing a thickening of the periosteum and a slight sclerosis of the medullary cavity. The patient had infected tonsils and cloudy sinuses, with a white blood count of 14,000.

Fig. 1-*B*. Same case as shown in Figure 1-*A*. A second X-ray film, taken one year later, showing the complete healing of the lesion.

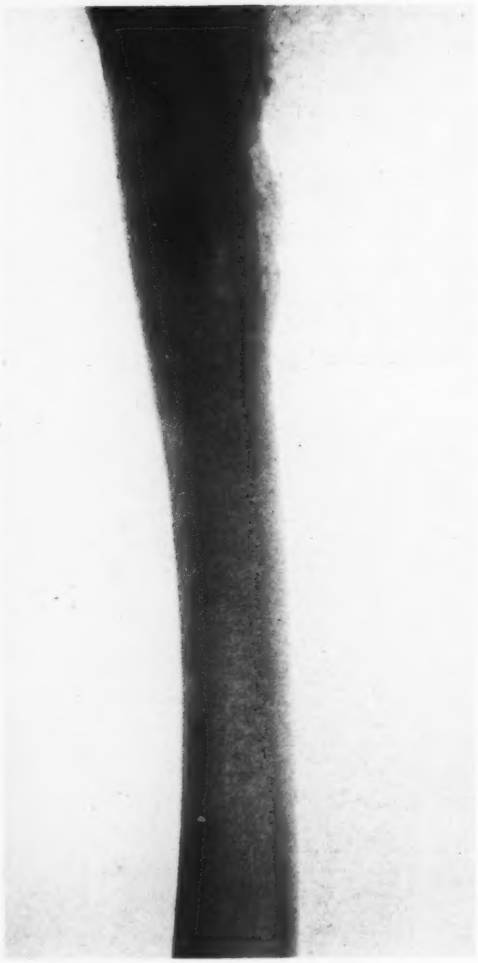

Fig. 2. Case 2. Roentgenogram showing new bone formation and bone destruction somewhat suggestive of sarcoma. Exploration showed granulation tissue only.

Because of the great difficulty in reaching a correct diagnosis and because the treatment depends so entirely upon the correct diagnosis, every means at one's disposal must be used to arrive at this important decision. A few days' delay will not affect the results. As in all bone lesions, the burden of proof should be to demonstrate the malignancy of the condition. A very careful history should be taken, a careful search made for a history of injury or of any acute infection, and above all an exhaustive examination must be carried out to locate any possible foci, however slight.

A number of cases have entered the clinic in which a differential diagnosis has been exceedingly difficult. Some patients with an initial diagnosis of sarcoma are well today without radical treatment of any kind.

In this group of cases, which is being reported as a group for the first time, there is a history of injury in two, bad teeth in one, a carbuncle in one, and osteomyelitis ten years before admission in another.

In all these cases pain in and an enlargement of the part affected were the symptoms of the onset, and in all cases the femur has been involved. A leukocytosis in all but one case has been present, while the Wassermann was negative in all.

Case 1.—Three months before entering the clinic the patient had an attack of "sciatica," affecting the right leg. Five teeth were extracted and the back was strapped. A few weeks later he noticed soreness and swelling of the right thigh. Two weeks later he had more pain and swelling. The diagnosis of osteogenic sarcoma was made by an outside doctor.

Examination.—The right thigh is much larger than the left and there seems to be a thickness of the femur at the upper and middle third. This thickness almost surrounds the entire femur. It is not tender.

Tonsils infected and sinuses cloudy. White blood count 14,000. Wassermann negative.

X-ray examination of chest negative. X-ray film shows a thickening of the periosteum but no real breaking through. There is a slight shadow in the medullary cavity and a tiny calcified spot about one and a half inches from the femur. This does not impress one as a malignant lesion, but, rather, as a benign infective process of osteomyelitis.

The patient was kept at rest. The tonsils

were removed and a submucous resection of the septum done.

Three months after we saw him, a sequestrum about 8 by 3 mm. was removed from the thigh. No gross pus was found at operation. Microscopic section did not show any sarcomatous change. Culture of tissue removed showed *Staphylococcus aureus*.

A second X-ray film made one year later shows the bone lesion to be entirely healed and the femur normal.

The final diagnosis was osteomyelitis, subacute type, with ossifying periostitis. This patient is perfectly well, two years later.

Fig. 3. Case 3. Antero-posterior and lateral views, showing marked sclerosis in the middle third of the femur, with suggestive sequestrum and involucrum. One year later a small piece of bone was removed in a pocket of pus at the site of the indentation shown in the film. The white count was 16,500.

Case 2.—Patient is a white male, aged 42. Five months before admission to the

clinic, the patient had a carbuncle on the lower portion of the left thigh which healed in two weeks. Following this, severe pain in the same leg developed, diagnosed and treated as "rheumatism."

Fig. 4-*A*. Case 4. Roentgenogram showing periosteal new bone formation in the upper femur, suggestive of early sarcoma. This film was made in January, 1924.

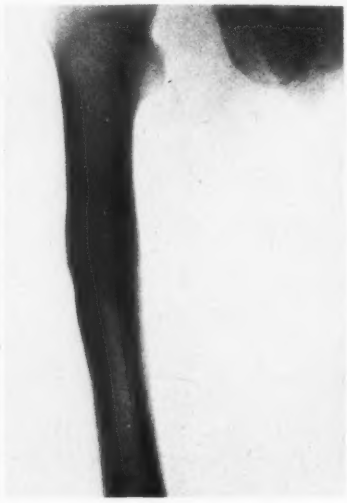

Fig. 4-*B*. Roentgenogram showing increased sclerosis and a shrinking in the periosteal new bone. This film was made in April, 1925, after a course of X-ray therapy had been administered.

On examination the left upper leg is found to be swollen about the middle third, tapering toward both the knee and the hip joints. The swelling extends around the entire leg, is rather hard, and gives the impression of bone formation. Wassermann negative. No temperature and no increase in leukocyte count.

X-ray examination shows new bone formation and bone destruction, chiefly on the medial side of the cortical bone, and some involvement of the marrow cavity. The X-ray findings suggest periosteal sarcoma.

Through fear of amputation, the patient left the hospital before operation. He later entered a hospital in Philadelphia, where exploration was done and a small piece of bone and tissue was removed. Microscopic section at this time showed new bone formation, with vascular cellular tissue between the bone and lamellæ, more typical of an inflammatory reaction than of a sarcoma.

This patient, following rest and hospital care after operation, made an uneventful recovery. The final diagnosis was osteomyelitis, subacute in type, with ossifying periostitis of the upper end of the femur.

X-ray examination three years after operation showed a healed bone lesion. Seven years later the patient was well.

Case 3.—The patient was a white male, aged 18. Sixteen months before X-ray films were received for diagnosis, the boy had hurt his leg while wrestling. His leg was sore for one or two days; there was no fever and no swelling; pain on pressure over right femur was noted. Following this injury, he worked as a plumber's helper and also danced for long periods of time. His leg began to hurt and was quite painful

Fig. 4-*C*. Roentgenogram of the arrested lesion, made in December, 1926, after further X-ray treatment. Same case as shown in Figures 4-*A* and 4-*B*.

Fig. 5-*A*. Case 5. Roentgenogram showing bone sclerosis and periosteal roughening in the right femur in a patient who had had osteomyelitis nine years previously (with apparent healing) in the right tibia.

after an all-night dance. Some slight fever and temperature resulted.

Examination of the boy showed some swelling over the right femur and some bony thickening, which seemed to extend completely around the femur. There was also a definite bulging of the soft parts in an irregular manner.

The X-ray film made after his first injury showed no bone change at all. X-ray films made after his second attack showed a very marked bony thickening of the middle third of the femur. It looked as though an involucrum and a sequestrum were present in the center of the shaft. The sequestrum seemed almost detached. There was some spicule formation along the outer border of the involucrum. This resembled a picture of osteomyelitis more than a sarcoma. Such light areas are rarely seen in sarcoma. At the lower end of the femur there was a definite bone cyst. The white blood count was 16,500; the blood Wassermann was negative. One year later X-ray examination showed a small piece of bone becoming detached, but no definite change in the main mass. Operation for removal of the small pieces of bone was performed.

Following the removal of two more detached pieces of bone a sinus developed, and this gradually healed without loss of more bone. Five years after his original attack the patient is well. The final diagnosis was osteomyelitis of the subacute type in the right femur.

Case 4.—The patient was a white male, aged 18, who was injured in a football game one month before admission. At this time he had a slight limp and complained of a great deal of pain, particularly at night. There was no swelling. He had been treated by an osteopath for three weeks, following which treatment there was some swelling.

The blood Wassermann was negative, and the white blood count was 15,850. On palpation we could feel a mass at the junction of the upper and middle third of the left femur, most marked on the lateral surface.

X-ray examination showed a definite soft-part tumor without bone. A definite area of destruction in the cortical layer beneath the new bone formation was visible. The new formation surrounding the entire shaft was suggestive of periostitis, and the marrow cavity was very suggestive of osteoporosis. This ruled out ossifying periostitis, and the diagnosis rested between osteomyelitis and sarcoma. In sarcoma, present so high in the femur, amputation as yet has not obtained a cure, and we must consider some form of sclerosing periostitis as a possibility. It would be wiser in this case to try X-ray therapy first and then cut down upon the tumor if necessary to settle the diagnosis.

X-ray treatment was given at intervals. Three months after treatment there was an area of breaking down, with pus formation, and a small piece of bone was removed. Six months after treatment the periosteal mass was distinctly smaller. The soft-part tumor partly disappeared. X-ray examination showed a healed process. X-ray findings of the lungs had been entirely negative throughout.

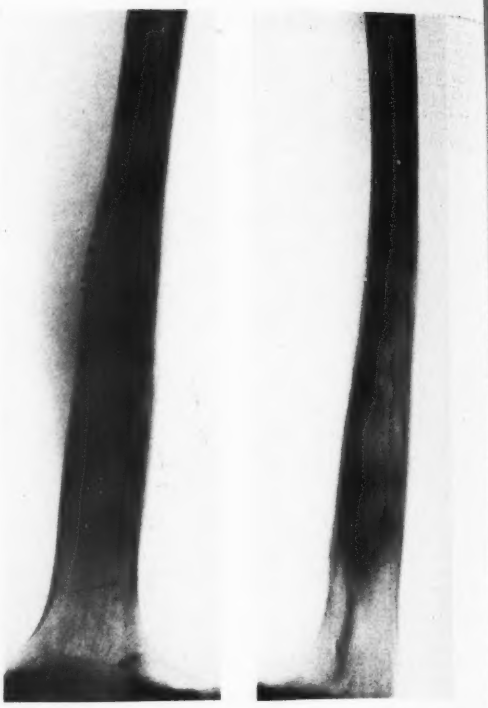

Fig. 5-*B*. Same case as shown in Figure 5-*A*. Roentgenogram made one month later, showing increased bone destruction.

It is now over seven years since this patient entered the clinic and since his injury, and, as far as our examinations can tell, he is perfectly well.

The final diagnosis was osteomyelitis with ossifying periostitis.

Case 5.—The patient was a white male, aged 25, who had had osteomyelitis of the right tibia when he was 16 years of age, which apparently had healed completely. At the age of 23 a small sinus developed over the old scar. This drained for five or six months and then healed. Two months before entering the clinic he had pain over the right thigh following a long automobile drive and a game of golf. There had been slight fever for one month.

On examination of this leg no soft-part infiltration was found, but the scar was adherent to the muscle. Some thickening of the bone around the lower third of the femur was present. There was no evidence of any acute disease or of a neoplasm; however, the patient felt a little tenderness over the scar.

The X-ray films in this case, taken one month apart, showed an area of destruction in the region of the medullary canal about the junction of the middle and lower third of the right femur. Surrounding this area there was an irregular thickening and some new bone formation. It did not suggest a neoplasm but rather a subacute osteomyelitis. About two months later, following excessive exercise, it again became sore, but under rest returned to normal and no operation was necessary. The final diagnosis was subacute osteomyelitis. The patient has been well over two years.

Had the diagnosis of sarcoma been made the most radical amputation possible would have been necessary with such extensive involvement of the bone and the lesion's position near the trochanter. This could not have offered more than a slight chance of a cure. The diagnosis of subacute osteomyelitis having been made in all cases, the summary of the treatment given is as follows:

Case 1.—Foci of infection removed or cleared up; removal of some sequestra, followed by proper rest and care. The patient has been well for two years.

Case 2.—Exploratory operation; removal of tissue for diagnosis, followed by proper hospital care. Patient lived for ten years.

Case 3.—Removal of sequestra and clearing up of foci of infection. Patient has been well for five years.

Case 4.—X-ray treatment; removal of sequestra. Patient has been well for seven years.

Case 5.—No operation; rest. The patient has been well for two years.

None of these cases had any radical operation performed, the main treatment being removal of any foci of infection present, followed by proper hygienic care.

LESIONS OF THE UPPER FEMUR

By GEORGE T. THOMPSON, BALTIMORE, MARYLAND

From the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University

TUMORS of bone of the upper femur present to the surgeon a problem which differs from that of lesions of bone elsewhere. The basis for this difference appears to be:

(1) The greatly increased liability of the upper femur to become the site of tumor metastasis;

(2) The inaccessibility of the upper femur, hiding all but large, advanced tumors unless they be specially examined for;

(3) The assumption that "sciatic" pains are physiologic;

(4) The increased liability of bone cysts to form here.

In any lesion of bone an accurate diagno-

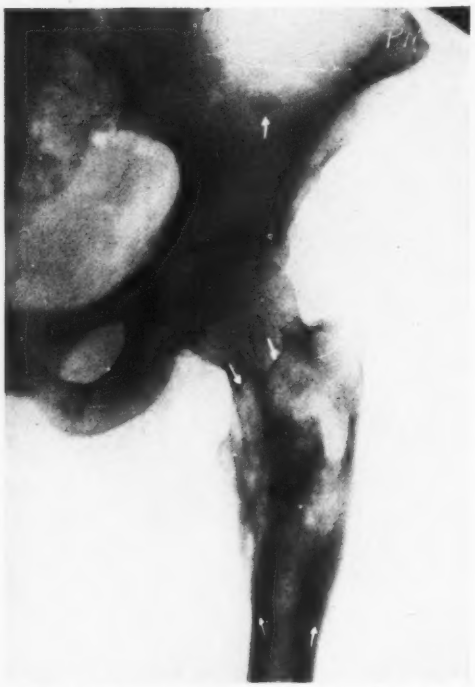

Fig. 1. Metastatic carcinoma. A white female, aged 54, came to her physician fifty-seven months after a radical amputation of a breast, presenting the above X-ray film. There was a local recurrence in the breast scar eighty months following the primary operation, and death, one month subsequently. The X-ray film shows patchy bone destruction, expansion of the shaft, and some new bone formation. Path. No. 35,420.

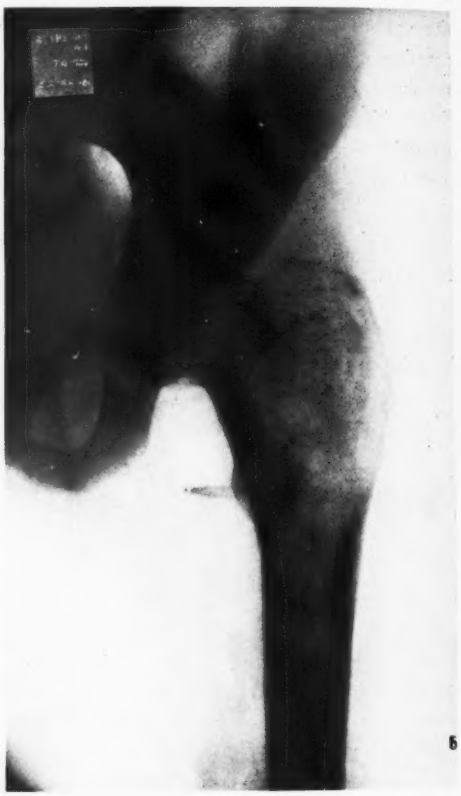

Fig. 2. Bone cyst. The patient was a white female, aged 14, who presented a history of pain in her hip and knee of nine days' duration. Operation was advised to prevent further bending deformity. The X-ray film, taken at the time of the first visit, shows an expansive tumor occupying the greater trochanteric region, with moderate coxa vara and little bone formation. Trabeculation is evident. An X-ray film taken three years later showed increased expansion of the cyst. One year after the X-ray film reproduced above was taken, a pathologic fracutre occurred. Path. No. 34,176.

sis is of the first importance if the surgeon is to give the patient the benefit of an operation when operation is needed, or the benefit of more conservative treatment when such treatment is indicated. The difficulties involved are, first, a diagnosis, and second, the fitting of the treatment to the diagnosis. Both of these offer problems peculiar to the upper femur.

Malignant lesions of the upper femur are not peculiar in their variety, including multiple myeloma, metastatic carcinoma, and the varieties of sarcoma. The situation is, however, altered by the fact that just over one-half of the malignant lesions at this site are metastatic growths. Of 71 malignancies of the upper femur that are recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, 36 are metastatic growths from tumors elsewhere. This group of 36 cases is thus removed from the possibility of surgical cure. Palliative measures—X-ray, radium, and Coley's serum—are all that the surgeon can offer the patient afflicted with such bone involvement. In case of the other malignant lesions, here as elsewhere, early diagnosis is of prime importance. Advanced cases make surgery ineffectual because of distant metastasis, and even in relatively early cases there are local difficulties.

The common history of lesions of the upper femur is that the patient first experiences pain in and about the hip, and goes to his local physician or chiropractor, who treats him for "rheumatism" by massage, light, etc. He continues this for a time, and finally he goes to some one who has the possibility of a bone tumor in mind, palpates for it, and makes an X-ray film. But the delay in diagnosis has made the chance of cure a hope rather than a probability. Had the tumor been in any other of the long bones, as the ulna, the tibia, or the humerus, where a tumor would have been readily palpated, probably by the patient himself, or where pain occasioned by the lesion would not have been labelled "sciatic" or "rheumatic" and considered as functional, discovery would in most instances have been much earlier and cure more likely. It is a significant fact that of the malignancies of the upper femur, recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, there are no five-year cures, whereas five-year cures of the sarcomas of the upper humerus, a more accessible bone, total four.

Fig. 3. Ossifying periostitis. The patient was a white female, aged 30, who had had trouble with her hip for seven years. At its inception the condition had been diagnosed as osteomyelitis. In the X-ray film, taken seven years after the onset of her trouble, there are seen calcified nodules, distant from the main calcified mass, and extensive ossification, suggesting bone formation on the basis of an old osteomyelitic or psoas abscess. A recent X-ray film, taken seven years after the one shown herewith, depicts the condition to be practically unchanged. Path. No. 33,958.

Of the benign lesions, less need be said. Their importance is largely a negative one—they must be recognized and differentiated from the malignant lesions. Nearly one-half are bone cysts. Symmetrical expansion of the bone shell, pathologic fracture, deformity due to long use of a weakened bone, age, and absence of symptoms make recognition without biopsy relatively easy. When

Fig. 4. Ewing's sarcoma. A white female, aged 14, who gave a history of pain and swelling of eighteen months' duration. Three and a half months after an exploratory operation the patient died. The X-ray film shows typical, onion-peel stratification in the newly formed bone, symmetrical expansion of the shaft, and no encroachment upon the marrow cavity. Path. No. 15,745.

fractured, they usually heal upon simple fixation.

Exostoses—usually discovered accidentally—are characterized by tumor only, with limitation of movement if the site is such that mechanical interference is produced. X-ray films are diagnostic. The possibility of change into a secondary chondromyxosarcoma must be borne in mind.

Recognition of giant-cell tumors and their differentiation, as in bone cysts, are more difficult at the head of the femur. Here there are three different and separate epiphyses, one each for the head, the greater trochanter, and the lesser trochanter. Thus the rule that giant-cell tumors develop only in the epiphysis and bone cysts only in the shaft becomes of less help in differentiating tumors of this region. (It is true that the upper humerus has three epiphyses, but they fuse with one another early, and later unite with the shaft.) The age of the patient is of the greatest help. Giant-cell tumors generally occur in patients over twenty-five; bone cysts, generally in patients under eighteen. Differentiation from chondrosarcoma, which is of more importance, is more difficult. The protracted clinical course, and the deformity of bone produced by weight-bearing in giant-cell tumors and bone cysts have distinct diagnostic significance.

Myositis ossificans—not properly a lesion of bone—can be recognized in the X-ray film by the intervention of a layer of non-osseous tissue between the ossified tumor and the underlying bone. A history of trauma is obtained.

Ossifying periostitis offers the same diagnostic problem here as in the other long bones. We must exclude Ewing's tumor, periosteal sarcoma, and scurvy in extremely young patients. Certain diagnosis, without biopsy, is sometimes impossible. A Wassermann test will sometimes save operation. Needless surgery is to be avoided, but operation to determine the nature of the lesion, where radical treatment—if it is malignant—will offer hope of cure or the greatest prolongation of life, is the procedure of choice when other methods of diagnosis fail.

The following table shows the distribution of tumors of the upper femur, recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital, compared to those of the upper humerus.

TABLE I

	Upper femur	Upper humerus
Ossifying periostitis	5	6
Myositis ossificans	3	1
Exostoses	18	22
Benign chondromas	1	2
Bone cysts	45	32
Giant-cell tumors	7	9
Ewing's tumor	8	2
Metastatic tumors	36	15
Multiple myeloma	4	6
Periosteal sarcoma	11	21
Fibrosarcoma	2	1
Osteolytic sarcoma	6	17
Total cases	146	134
Total malignant lesions	67	62
Total benign lesions	79	72
Percentage malignant	46	46
Number of 5-year cures	0	4
Percentage of 5-year cures	0	6.4

PATHOLOGIC FRACTURE

By E. DAVID WEINBERG, M.D., BALTIMORE, MARYLAND
From the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University

IN a study of 1,700 bone tumors of all types, benign and malignant, there were found 160 pathologic fractures. The largest incidence, 62 per cent, occurred in multiple myeloma; 45 per cent were found in bone cysts, and in the group of metastatic carcinomas there were 33 per cent.

Naturally, we would expect the largest number of pathologic fractures to occur in the bone lesions which are characterized by bone destruction, with little or no bone production. This explains the high incidence in multiple myeloma and bone cysts. We find an exception, however, in giant-cell tumors, probably accounted for by their location near the epiphysis, whereas the other lesions occur as a rule in the shaft of the bone. We find a higher incidence of pathologic fractures in metastases from carcinoma of the breast as compared to metastases from carcinoma of the prostate. In the latter case, there is comparatively little bone destruction and more new bone formation, while in the former, there is a great deal of bone destruction with little or no new bone formation. In the periosteal type of sarcoma there is a diffuse or periosteal involvement at first. In this type, pathologic fracture occurred in only 3.7 per cent of the cases, whereas it was present in 35 per cent of the osteolytic type of sarcoma. Among the exostoses, we have seen no instance in which the fracture has occurred from the disease, although it is possible in cases in which there is a history of trauma sufficient to cause a fracture in a normal bone.

TABLE I

Types of tumors	Percentage of pathologic fractures
Exostosis	1½%
Bone cyst	45%-50%
Giant-cell tumor	14%
Chondromyxoma	15%
Multiple myeloma	65%
Metastatic carcinoma	33%
Sarcoma (osteolytic)	35%
Sarcoma (periosteal)	3.7%

Fig. 1. Pathologic fracture through a benign bone cyst in the upper end of the femur. The femur is the bone most frequently the seat of pathologic fracture and the benign bone cyst is a tumor in which pathologic fracture most often marks the onset of clinical symptoms. This fracture healed spontaneously.

The rôle the pathologic fracture plays in the symptomatology varies with the type of tumor. In bone cysts, it is the symptom of onset in 38 out of 55 fractures. In only one instance in 15 fractures was it the factor which disclosed the underlying giant-cell tumor. Here, we usually get a history of pain, swelling, stiffness, and trauma before the fracture occurs. In none of the pri-

mary sarcomas or metastatic growths is the fracture the primary symptom. Geschickter and Copeland (1), in their extensive and able study of multiple myeloma, state that, "while a pathologic fracture is not infrequently the source of the first symptom of onset, it is less frequently recognized in itself as an initial sign of the disease."

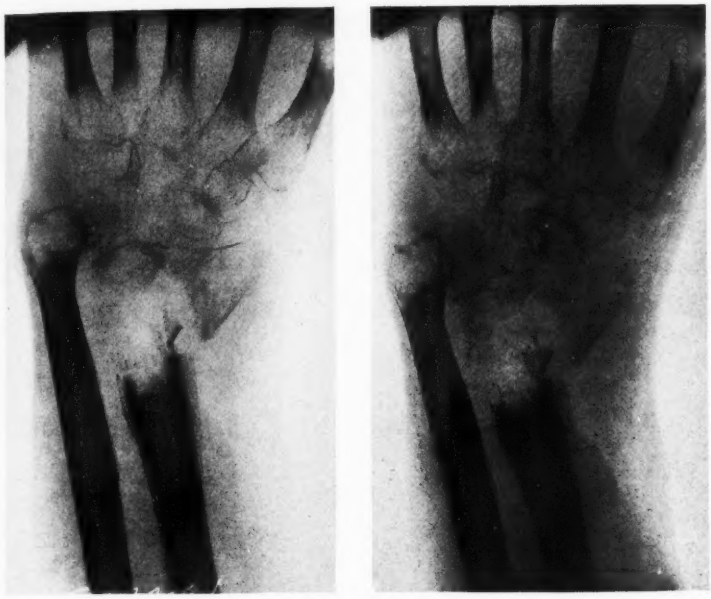

Fig. 2. Pathologic fracture in a benign giant-cell tumor of the lower radius. The lower end of the radius is the most frequent site of this type of tumor. These fractures in giant-cell tumors do not heal unless the disease is treated.

Nearly every bone in the body has been the site of pathologic fracture. The femur is by far the most frequently involved, the humerus being next. Multiple myeloma is characterized by the fact that it usually involves the bones of the thorax—the ribs, sternum, vertebræ, and clavicles—whereas the other tumors seem to have a predilection for the long pipe bones. In multiple myeloma we also have instances of several pathologic fractures occurring in different bones at the same time. Bone cysts occur most commonly in the upper end of the femur, the upper end of the humerus, and the upper end of the tibia.

Ossification of these fractures in the different groups also shows a tremendous variation. In bone cysts they always heal, and, if the fracture is extensive enough, it will also cause the cyst to ossify. In giant-cell tumors, we find that not one healed when the fracture occurred through the central part of the tumor. When the lesion perforates the bone shell there is evidence of ossification in the shell only. This tumor seems to destroy all osteoblastic power of the involved bone. In four of the cases of sarcoma in which there was a history of fracture, the fractures occurred in bones which, on X-ray examination, revealed no other abnormalities. The fractures healed, and, at a later date, sarcoma developed. In

one case, a fracture occurred in a bone which showed areas of osteoporosis. The fracture healed, but eleven months later a typical sarcoma developed. Therefore, while ossification may occur in this group, by operation is necessary. In giant-cell tumors, we have four modes of attack: *(a)* irradiation; *(b)* curettement, with thermal cauterization; *(c)* resection; *(d)* amputation.

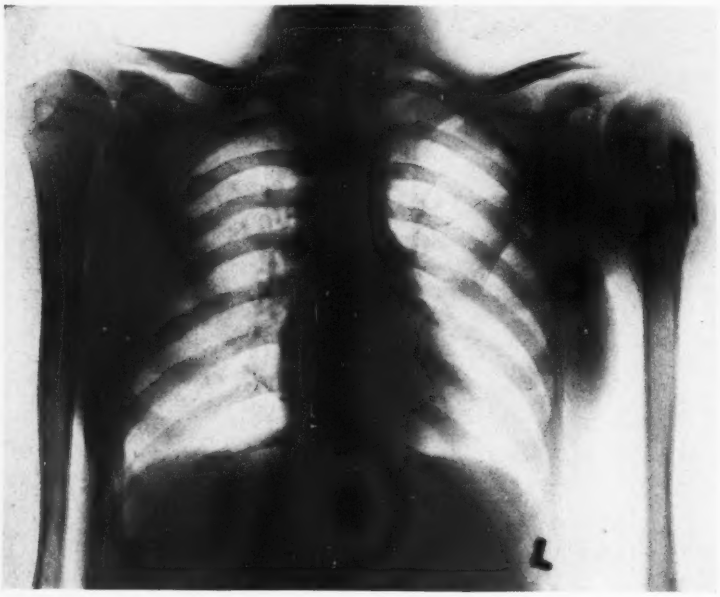

Fig. 3. Pathologic fracture in the upper humerus, which is the seat of an osteolytic sarcoma. Healing never takes place in this type of fracture, and the prognosis in this disease is extremely poor.

it is quite rare. In some of the cases of multiple myeloma, there are evidences of ossification within a normal period; in others, union is delayed, while some do not heal at all. In an atypical case reported by Geschickter (*2*), there was a pathologic fracture. It was splinted, and healed; some time after the splint had been removed, however, a refracture took place. This one also healed, with splinting.

The treatment of the fracture varies with the type of tumor in which it has occurred. In a bone cyst, we simply immobilize. If the fracture is not complete or if the cyst does not ossify, crushing of the bone shell

Treatment depends on the location and extent. Herendeen (*3*) claims that if X-ray dosage is not too strong, healing will occur. However, the treatment is prolonged, more uncertain, and without the advantage of biopsy. In malignant disease the treatment is rarely centered around the pathologic fracture, unless the fracture occurs during a course of irradiation, or subsequent to a local operation. In such instances, splinting and irradiation should be used in an attempt to restore the continuity.

The fracture, however, has a distinct place both in the diagnosis and the treatment of the malignant condition itself. In car-

tilaginous tumors involving the long bones, with medullary destruction, a pathologic fracture is usually an indication of some variant of chondrosarcoma. In other types of sarcoma as well as this type, the presence of a fracture favors radical treatment, preferably amputation or radical resection, as it renders the limb useless.

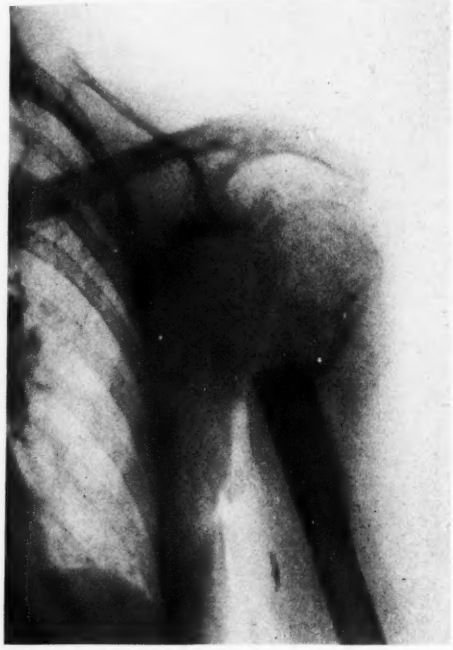

Fig. 4. Fracture in a case of multiple myeloma. In addition to the lesion in the humerus, smaller areas of involvement can be seen in the clavicle, ribs, and scapula. Multiple myeloma has the highest incidence of pathologic fracture of all bone tumors. In rare cases these fractures may heal, although the prognosis for the disease itself is hopeless.

Fig. 5. A case of metastatic carcinoma, with marked destruction and fracture of the femur. Healing of the fracture is very rare in cases of metastatic carcinoma to bone, and the outcome of the disease is practically always fatal.

In the bones of the hand and in those of the foot (with the exception of the os calcis), there are no malignant lesions among the entire 1,700 cases. The majority are chondromas and bone cysts, while a few are of the giant-cell type. One can, therefore, treat such fractures by immobilizing them to determine if they ossify. If no union occurs, cauterize the tumors with the thermal cautery, or curet and cauterize with zinc chloride. Treated otherwise, they will recur.

Geschickter (4) is of the opinion that there is a histological and clinical paradox in chondromas or chondromyxoma. From his clinical experience, and from an intensive follow-up system, it seems that the chondromas of the bones of the hands and feet (with the exception of the os calcis) clinically are always benign. In the large bones, the long pipe bones, and the sternum they are always potentially malignant. Nevertheless, histologically, the sections of the tumors from the large bones nearly

always appear benign, while sections taken from the same type of tumor in the carpal and tarsal bones practically always appear to be malignant.

with some destruction, it favors the diagnosis of a chondrosarcoma as against a benign chondroma.

From the standpoint of treatment—

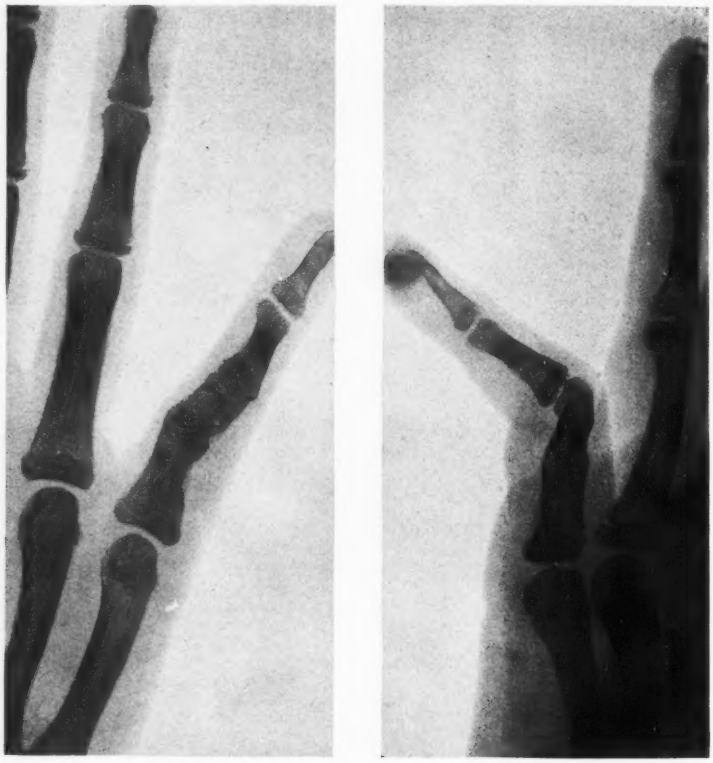

Fig. 6. A central chondroma of the phalanx of the little finger, showing a pathologic fracture. The finger in such a case can be saved by curetting and cauterizing with 50 per cent zinc chloride and then splinting.

SUMMARY

From the standpoint of diagnosis, pathologic fracture is helpful—

(1) As a symptom of onset in a central tumor of the shaft. In a patient from five to fifteen years of age, the lesion is, most likely, a bone cyst.

(2) Occurring in a rib of an adult, it favors multiple myeloma.

(3) If the lesion is a cartilaginous one in a long pipe bone, and there is a fracture

(1) A pathologic fracture is a good sign in a bone cyst, and it is to be treated as a simple fracture.

(2) Immobilize fractures in tumors of the bones of the hands and feet. If no ossification takes place, cauterize with the thermal cautery or curet and cauterize with zinc chloride.

(3) Occurring in multiple myeloma and giant-cell tumors, we are justified in splinting and using deep X-ray therapy, hoping to obtain healing in multiple myeloma, and a

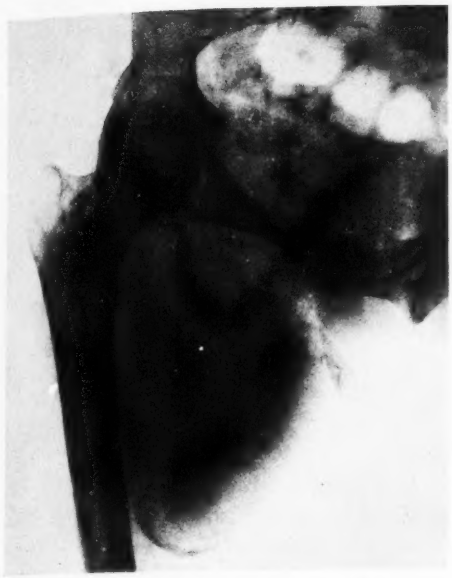

Fig. 7. A case of periosteal osteogenic sarcoma of the pelvis, producing splintering and fracture of the ischium. This sarcoma was of the chondrosarcoma type and was secondary to an osteochondroma of the pelvis. This patient died in spite of deep X-ray therapy.

cure in giant-cell tumor, unless it is too far advanced.

(4) In sarcoma and metastatic carcinoma, a pathologic fracture in a long bone generally indicates radical treatment—either a resection or an amputation—because the limb will otherwise be useless and painful. Finally, by precautionary measures, such as crutches or splints, we can often prevent a pathologic fracture in a destructive lesion.

REFERENCES

(1) GESCHICKTER, C. F., and COPELAND, M. M.: Multiple Myeloma. Arch. Surg., April, 1928, XVI, 807-863.

(2) GESCHICKTER, C. F.: Multiple Myeloma as Single Lesion. Ann. Surg., September, 1930, XCII, 425-433.

(3) HERENDEEN, R. E.: Giant-cell Tumors of Bone, with Special Reference to Treatment Technic. Am. Jour. Surg., January, 1930, VIII, 122.

(4) GESCHICKTER, C. F.: Personal communication.

EDITORIAL

WORKING RULES FOR LESIONS OF THE BONE

As experience accumulates in the larger clinics where the diagnosis of bone lesions is a daily problem, it becomes increasingly evident that certain working rules can be formulated, which will simplify greatly the problem of diagnosis and facilitate accuracy in the procedures recommended at consultation. Too often when an important decision is to be made by the consultant, the initial steps taken in the case have been inadequate or ill advised and much valuable time is lost. For this reason an attempt has been made to set up the following working rules which are subject to revision in the light of subsequent experience.

THE RULES OF PROCEDURE

1. Take X-ray films after every severe injury followed by pain on motion of the part, or when there is increasing tenderness, swelling, and pain over the bone. The films should be retaken if not clear, and views should be obtained in two different directions.

2. Take an X-ray film of the opposite side for comparison; early changes are otherwise indiscernible.

3. Multiple foci of pathology or diffuse lesions in bone or about a joint in the first film taken demand a film of the entire pelvis (lumbar spine and upper femurs included) and chest (with upper arms included) to rule out multiple bone or joint involvement, which usually contra-indicates surgery, and narrows the possibilities for diagnosis. An examination of the urine for Bence-Jones bodies is also essential.

4. Take a complete history and do a thorough physical examination, with special emphasis on palpation and search for a primary focus of infection or cancer outside of bone. Strive to rule out acute osteomyelitis by history and examination, for in no other lesion of bone is a moderate degree of delay costly.

5. If acute osteomyelitis is ruled out, use the X-ray film for consultation when in doubt, before surgery. Surgery is rarely indicated in the multiple lesions and in the minority of single lesions. There is no harm in waiting for a confirming opinion.

6. While waiting, put the part at rest and give deep X-ray or radium therapy to determine radiosensitivity. Four out of eight types of solitary bone tumors are radiosensitive—this provides a therapeutic test.

7. Regardless of the diagnosis, do not operate without a Wassermann reaction report.

8. Before operating for a malignant lesion of bone take an X-ray of the chest to rule out metastases.

9. Pulmonary metastases in a film of the chest are not proved unless there is fluid in the chest, cachexia, or a recurrent tumor or metastatic gland elsewhere in the body. A chest film does not contra-indicate surgery, if signs of metastases are doubtful.

10. Do not explore a doubtful tumor unless adequate provision has been made for

the interpretation of the biopsy material and for a radical operation if indicated.

11. If a previous operation has been done make every attempt to secure sections or tissue for examination.

12. Always explore the tumor before amputating, complying first with Rule 10, using a tourniquet and preferably the cautery or electric needle.

RULES FOR DIAGNOSIS

1. Tumors of the small bones of the hands and feet (excluding the os calcis) are usually benign.

2. A central tumor of the sternum is a benign chondroma.

3. A central bone-destructive lesion in the epiphysis of the lower radius which expands the cortex is practically always a giant-cell tumor.

4. Diffuse bending or bowing of the bone is in favor of a benign lesion.

5. Multiple lesions in children and in adolescents up to twenty years of age are benign, excepting bone dissemination from malignancy in internal organs, and in late Ewing's tumor. Multiple lesions in adults are malignant, except Paget's osteitis deformans and osteomalacia, and distinctly joint lesions.

6. A protracted history in adults is in favor of a benign lesion, with the following outstanding exceptions:

(a) Secondary chondrosarcoma occurring in benign exostoses or chondroma.

(b) Secondary osteolytic sarcoma at the site of an old infection or trauma.

(c) Sarcoma arising in Paget's osteitis deformans.

(d) Sarcoma arising in recurrent myositis ossificans

7. Lesions characterized by periosteal bone formation in adults are usually benign, whereas in patients under twenty this usually indicates malignancy unless the bone formation surmounts a pedicle of normal bone.

8. Malignancy following upon a benign bone cyst or a benign giant-cell tumor has never been proved although a central chondroma resembling these lesions may undergo sarcomatous change.

9. In young patients under twenty, lesions which are predominantly osteolytic are usually benign, with the exception of osteolytic sarcoma; and lesions with bone formation within the cortical confines in the medullary spaces, also are usually benign, with the exception of early Ewing's tumor. Osteolytic sarcoma is indicated by a marked destruction of the cortex without expansion, and Ewing's tumor by being radiosensitive.

10. In patients over thirty (adults) bone-destructive lesions that escape beyond the cortex are usually malignant unless occurring in an epiphysis (giant-cell tumor), in the small bones of the hand or foot (chondroma), or at a joint (tuberculosis). Periosteal bone formation predominating in adults is usually benign. Distinctly periosteal bone formation in young patients, unless surmounting a pedicle of normal bone, is usually malignant.

RULES FOR TREATMENT

1. Where the Wassermann reaction is positive, a course of antisyphilitic treatment is essential before instituting surgery.

2. Deep X-ray therapy should be discontinued in favor of surgery if definite results are not obtained in six weeks.

3. A sarcoma at the upper end of the femur has never been cured by amputation.

4. In the bones of the arm and the fibula, a radical resection offers as much for the cure of malignant disease as does amputation.

5. Unless multiple bone involvement is inflammatory beyond exception, surgery is contra-indicated.

6. The following tumors of bone are radiosensitive: *(a)* Ewing's sarcoma; *(b)*

chondral forms of osteogenic sarcoma; *(c)* highly cellular forms of fibrosarcoma; *(d)* giant-cell tumor and giant-cell variants of bone cysts.

7. Pain is relieved and life lengthened by irradiation in metastatic carcinoma.

8. Deep X-ray therapy may be used to control pain in bone disease temporarily except in cases in which there is an acute infection.

9. Pathologic fractures may heal in any form of bone disease and never in themselves constitute a cause for amputation.

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